Project Yellow – Bringing Data Types and Functional Programming to Excel

Virtual Master Class – Andy Gordon Senior Principal Research Manager Microsoft Research

London Tech Centre – JPMorgan Chase April 28, 2020

Future of Work Calc Intelligence



Transforming the world through deep research



Project Yellow

Excel as a Programming Language A long-term partnership between Excel and MSR Cambridge

Presented by Andy Gordon, MSR Cambridge – adg@microsoft.com

Microsoft Research

Aim

Remove the "glass ceiling" that limits the scope and reach of what a domain expert can do with Excel:

 Make Excel functions reflect the abstractions of our end users, by allowing end-users to define new functions using an ordinary worksheet.

 Make Excel's data values reflect the datatypes of our end users' domains, by adding arrays, vectors, records, and even domainspecific data types implemented by third parties.

So far, we've taken Excel beyond text and numbers

So f	ar, we	've taken	Excel I	beyond	text and	Inumb	oers		gnite	20						
1	A	B C	D	E	F G	Н	I	J	К	078						
1	Dynan	nic Arrays														
2	· L															
3	Sort y	our data	Clean	your data	F	ilter your d	data									
4	Names	ort your dataClean your dataFilter your dataesSortedNamesNo DupNamesChoiceVeg OnlyPeterPeterMaryMeatrJanePeterVegJaneJohnVegonAlisonSimonMeat														
5	Mary		Peter		Mary	Meat										
6	Peter		Jane		Peter	Veg										
7	John		Jane		John	Veg										
8	Simon		Alison		Simon	Meat										
9	Charles		Simon		Charles	Veg										
10	Jane		Mary		Jane	Meat										
11	Alison		Simon		Alison	Veg				1						
12			Charles													
13			Charles													
14			John													
15									Ŧ							

So far, we've taken Excel beyond text and numbers

Image: Control Partier I	Image: Series Segret II III III Image: Series Se	File Home	insert Pa	ge Layout 🛛 F	ormulas Dat	a Review V	iew Developer	Add-ins	Help	Design	€ Search	h				년 Share	₽ co	mment	ts
Image: Construct Parties Image: Construc	Image: Construint B I Image: Construint S	Cut	Segoe UI	- 14	- A* A* =	= = 🗞 -	Wrap Text	General					· 🖽 8	🗵 🗐] ∑ AutoSi	um × AZZ	Q	4	
Cipboard Fort Alignment Inter Styles Cells Editing Ideas ALD Image: Styles Fort Image: Styles Fort Image: Styles Cells Editing Ideas ALD Image: Styles Fort	Cipboad G Port Algement Number Style Cells Editing Ideas 0 Image: Control Strong Production 00000 persons Image: Control Strong Production Image: Control Strong Production 00000 persons Image: Control Strong Production Nonthest 3.04 0.04 0.04 0.04 Image: Control Strong Production Nonthest 3.04 0.04 0.04 0.04 Image: Control Strong Production Nonthest 3.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	aste 🦪 Copy 🔹	B I J	u - ⊞ - <mark>.</mark>	<u>0 - A</u> - ≣		🗄 Merge & Center	- \$ - %	9 58 -88	Condition	nal Formata: g ~ Table ~	s Cell Styles -	Insert De	lete Form	at Clear	Sort & F	ind & I elect ~	deas	
ALD I X K M V P 0 No State 1 Bogint M Coffee Shops per 4024277 17 13:733 0.000 Purchas 00000 Persons 00000 Walkhama South 48 7016;270 72 25:525 16:60 10:000 Persons 00000 Walkhama South 48 7016;270 72 25:525 16:60 17:735 0.040 Walkhama South 53 800:01:154 16:80:051:154 16:80:051:154 16:80:051:154 16:80:051:154 16:80:051:154 16:80:02:01:154 16:80:02:01:154 16:80:02:01:154 16:80:02:01:154 16:80:02:01:154 16:80:02:01:154 16:80:02:01:154 16:80:02:01:154 16:80:02:01:154 16:80:02:00:02:01:00:00:00:00:00:00:00:00:00:00:00:00:	0 v v v v v v v v v v v	Clipboard	5	Font	74	Alignme	nt	ra Numt	ber 🕠		Styles		c	ells		Editing	1	deas	
A B C D E P O H J K L M N O P O R S T U State I Region Coffee Shops per Population 1000 orgunar kms Amas 1000 orgunar kms 1000 orgunar kms Amas 1000 orgunar kms 1000 org	A B C C F G I J K M N P A S T U State Region Coffee Shops P Population 100.000 persons Aras 100.000 persons Aras <t< th=""><th>.10 - :</th><th>XV</th><th><i>f</i>_x Florida</th><th>1</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></t<>	.10 - :	XV	<i>f</i> _x Florida	1														
Number of Elstes Coffee Shopp pr Io0.000 persons Coffee Shopp pr Ion.000 persons Coffee Shopp pr Ion.000 persons Participation Region Average BZ Alabama Balabama South 6.8 4.974,747 1.7 135,765 0.030 9 0.000 Persons Modest 3.04 9 BZ Alabama Balabama South 6.8 4.974,747 1.7 135,765 0.040 9 0.000 Persons Modest 3.04 9 0.000 Persons Modest 0.000 Persons Persons Persons Persons Persons Persons	Coffee Shops per State Coffee Shops per 100.000 Persons Mich est State State 488 All State 273 Del State Coffee Shops per 100.000 Persons Mich est State 3.04 Mich est State 288 1.05 29.05 3.1 1.33.00 2.10 2.33 2.10 2.30 2.10 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30 2.30	A	в	c	D	E	F	G	н	J	κL	M	N O	P	Q	B	s	T	U
State I Region Coffee Shops Pare 100,000 persons Area 2000 Coffee Shops by Region per 100,000 Persons Region A verage Dialabara Pacific 49 739,795 6.61,717,854 0.03 0.04 0.000 Persons Midwest 3.04 0.00 Dialabara Pacific 49 739,795 6.61,717,854 0.03 0.04 0.000 Persons Midwest 3.04 0.000 Persons Midwest 3.04 0.000 Persons Midwest 2.04 0.000 Persons Midwest 0.000 Persons Midwest 3.04 0.00 0.000 Persons Midwest 0.00 Pacific 6.78 0.00 0.000 Persons Midwest 0.00 Pacific 6.78 0.000 Persons Midwest 0.000 Perso	State Region Confect Shops Population None Average Walkahama South 55 447.477 17 135.765 0.03 Markana South 55 447.477 17 135.765 0.03 Markanas South 55 4.047.477 17 135.765 0.03 Markanas South 55 3.04.279 1.4 137.733 0.040 Dicalization West 222 39.356.653 7.1 423.970 6.652 3.71 Dicalization West 223 3.588.164 3.4 14.357 8.77 Dicalization South 25 96.19.99 2.6 6.422 3.72 Dicalization 799 3.1 13.5300 2.12 3.38.80 2.23 0.31 Differidia Rescingate fin 538 6.9 28.311 2.50 6.62 0.33 Differidia Rescingate fin 538 6.9 2.8311 2		Nu	mber of	Cot	fee Shops per	Coffee S	hops per	13									_	
IIII Alabama South 85 4.874,747 1.7 135,765 0.68 III Alabama South 85 4.874,747 1.7 135,765 0.68 0.02 III Alabama South 55 3.004,279 1.8 137,733 0.40 0.00 III Alabama West 281 393,356,53 7.1 423,970 6.66 0.66 III Colorado West 281 350,8164 3.4 137,733 0.40 III Colorado West 358,164 3.64 143,577 8.577 1.8 137,733 0.40 IIII Colorado West 3.581,164 3.64 2.6 6.652 3.87 1.77 IIII Colorado West 3.83 6.6 28,311 3.50 1.77 2.6 6.62 0.31 3.72 IIII IIII IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	Citabiana South 65 4,874,747 1.7 135,765 0.63 Citabiana South 49 739,755 6.65 1.77,1854 0.03 Citabiana South 53 7.016,270 7.0 295,254 1.65 Citabiana South 53 3.004,279 1.8 137,733 0.40 Citabiana West 428 7.016,270 7.0 295,254 1.65 Citabiana West 282 393,56,653 7.1 423,970 6.65 7.00 Colorado West 481 5.607,154 8.6 269,637 1.78 Citabiana South 2.25 961,939 2.6 6.452 3.87 Citabiana South 2.5 961,939 2.6 6.452 3.87 Citabiana South 2.5 961,939 2.6 6.452 3.87 Citabiana Materiatiana 1.102,43 3.9 216,632 0.01 Citabiana Materiatiana 1.102,43 3.9 216,632 0.01 <	State 🚽	Region - Col	ffee Shops 💌 P	opulation 💌 100	,000 persons 💌 /	Area 💌 1,000 squ	uare kms 💌								-			
IIII Alaska Pacific 49 739 795 6.6 1,717,854 0.03 IIII Alaska Pacific 49 739 795 6.6 1,717,854 0.03 IIII Alassas South 55 3,004,279 1.8 137,733 0.40 IIII Colorado West 2.821 39,536,653 7.1 423,970 6.66 6.67 5000 2.73 South 2.69 West 6.20 Grand Total 3.72 IIII Colorado South 2.5 961,939 2.6 6.452 3.87 1.75 900,033 170,304 4.06 IIII Colorado 739 3.1 153,909 2.12 3.8 6.0 2.831 3.55 0.0 1.0 0.0	CDLAISLA Pachic 49 739,795 6.6 1,717,854 0.03 DirAtzona West 488 7016,270 70,295,254 1.65 DirAtzona West 281 93,36,653 71,429,970 6.65 DirColorado West 281 93,36,653 71,429,970 6.65 DirColorado West 281,953 6.64,52 3.67 DirColorado West 285,864 3.4 14,337 8.77 DirColorado West 28,964,00 739,173,34 4.00 3.3 170,304 4.00 DirColorado Pachics 273 -4.00 3.3 170,304 4.00 Confection 739,133 13,39,090 2.12 0.31 3.3 0.01 93 3.6 9,23 0.01 93 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 <	@ Alabama	South	85	4,874,747	1.7	135,765	0.63	Cott	ee Shops by	Region per 1	00,000 Pe	trsons		Region	 Average 			
Markanasa West 488 7,016,270 7,0 295,284 1.65 Markanasa South 53 30,04,279 18, 137,733 0.40 Markanasa South 52 30,536,653 7,1 423,970 6,65 Markanasa Markanasa 148 5,667,154 6,6 6,682 3,67 Markanasa 128 5,667,154 6,6 6,482 3,87 Markanasa 123 5,881,164 3,4 14,337 8,57 Markanasa 123 5,881,164 3,4 14,337 8,57 Markanasa 123 5,891,1939 2,6 6,452 3,87 Markanasa 123 5,993,93 2,6 6,452 3,87 Markanasa 138 5,9 2,81,11 3,50 9,1 Markanasa 138 3,9 216,652 0,31 0,00 Mindaha 133 3,9 216,652 0,31 0,00 Mindaha 133 3,9 216,652 0,31 0,00 Mindaha 134 3,9 216,652 0,31 0,00 Mindaha 133 14,357,33 0,40 0,44 0,46 <td< td=""><td>Official Control West 488 7/06/270 7/0 295/254 1.05 DirAtransas South 55 3.004.279 1.8 137/733 0.40 DirCanfornia West 2221 39.356.653 7.1 423.970 6.65 DirConnectruct NorthEast 2.23 3.588.164 3.4 14.357 8.67 DirConnectruct NorthEast 2.23 3.588.164 3.4 13.57 8.77 DirConnectruct NorthEast 2.23 4.837 8.67 8.67 9.69 DirConnectruct NorthEast 2.23 4.837 8.67 9.69 9.69 DirConnectruct NorthEast 2.3 153.909 2.12 9.69 9.69 DirConnectruct NorthEast 1.3 13.92 0.60 0.41 9.63 13.1 3.69 2.21 DirConnectruct NorthEast 1.3 2.2 10.96 0.41 9.64 0.61 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 <td< td=""><td>@ Alaska</td><td>Pacific</td><td>49</td><td>739,795</td><td>6.6</td><td>,717,854</td><td>0.03</td><td></td><td></td><td></td><td></td><td>Series]</td><td></td><td>Midwest</td><td>3.04</td><td></td><td></td><td></td></td<></td></td<>	Official Control West 488 7/06/270 7/0 295/254 1.05 DirAtransas South 55 3.004.279 1.8 137/733 0.40 DirCanfornia West 2221 39.356.653 7.1 423.970 6.65 DirConnectruct NorthEast 2.23 3.588.164 3.4 14.357 8.67 DirConnectruct NorthEast 2.23 3.588.164 3.4 13.57 8.77 DirConnectruct NorthEast 2.23 4.837 8.67 8.67 9.69 DirConnectruct NorthEast 2.23 4.837 8.67 9.69 9.69 DirConnectruct NorthEast 2.3 153.909 2.12 9.69 9.69 DirConnectruct NorthEast 1.3 13.92 0.60 0.41 9.63 13.1 3.69 2.21 DirConnectruct NorthEast 1.3 2.2 10.96 0.41 9.64 0.61 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 <td< td=""><td>@ Alaska</td><td>Pacific</td><td>49</td><td>739,795</td><td>6.6</td><td>,717,854</td><td>0.03</td><td></td><td></td><td></td><td></td><td>Series]</td><td></td><td>Midwest</td><td>3.04</td><td></td><td></td><td></td></td<>	@ Alaska	Pacific	49	739,795	6.6	,717,854	0.03					Series]		Midwest	3.04			
Clip Arkansas South S5 3,004,279 1.8 137,733 0.40 West 2821 39,356,55 7.1 423,970 6,65 7.1 7.8 West 6,78 West 6,78 DC Concerciout NorthEast 123 3,588,184 3.4 143,577 6,57 West 6,30 Grand Total 3,72 DD clavare South 2.5 961,939 2.6 6,452 3,87 0,40 Concerciout NorthEast 123 3,588,184 3.4 143,577 8,57 DD clavare South 2.8 66,9 28,311 3.50 DI claina 177,733 0,400 3.3 170,304 4.00 3.7 0.70 0.71 0.72 0.72 0.72 0.72 0.72 0.72 0.72 0.72 0.72 0.72 0.73 0.71 0.82 0.73 0.71 0.72 0.72 0.73 0.71 0.73 0.72 0.72 0.71 0.72 0.72 0.73 0.71 0.72 0.72 0.73 0.71 <td>CDL/Farsas South 55 3.004,279 1.8 137,733 0.40 Collocado West 2821 89,586,653 7.1 423,970 6.65 Colocado West 481 5.607,154 8.6 269,897 1.7.18 Colocado Vest 481 5.607,154 8.6 269,897 1.7.18 Colocado Vest 23 588,184 3.4 143,57 8.57 Colocado Vest 23 5.667,154 8.6 269,837 1.7.18 Colocado Vest 2.59 961,939 2.6 6,452 3.87 Colocado Vest 2.59 961,939 2.6 6,452 3.87 Colocado Vest 3.3 170,304 4.08 4.7 4.83 4.9 4.83 4.9 4.83 4.9 4.83 4.9 4.83 4.9 4.83 4.6 4.83 4.6 4.83 4.6 4.8 4.6 4.83 4.6 4.8 4.6 4.8 4.6 4.8 4.6 4.8 4.6 <</td> <td>四 Arizona</td> <td>West</td> <td>488</td> <td>7,016,270</td> <td>7.0</td> <td>295,254</td> <td>1.65</td> <td>2</td> <td>(Income</td> <td></td> <td></td> <td></td> <td></td> <td>NorthEast</td> <td>2.73</td> <td></td> <td></td> <td></td>	CDL/Farsas South 55 3.004,279 1.8 137,733 0.40 Collocado West 2821 89,586,653 7.1 423,970 6.65 Colocado West 481 5.607,154 8.6 269,897 1.7.18 Colocado Vest 481 5.607,154 8.6 269,897 1.7.18 Colocado Vest 23 588,184 3.4 143,57 8.57 Colocado Vest 23 5.667,154 8.6 269,837 1.7.18 Colocado Vest 2.59 961,939 2.6 6,452 3.87 Colocado Vest 2.59 961,939 2.6 6,452 3.87 Colocado Vest 3.3 170,304 4.08 4.7 4.83 4.9 4.83 4.9 4.83 4.9 4.83 4.9 4.83 4.9 4.83 4.6 4.83 4.6 4.83 4.6 4.8 4.6 4.83 4.6 4.8 4.6 4.8 4.6 4.8 4.6 4.8 4.6 <	四 Arizona	West	488	7,016,270	7.0	295,254	1.65	2	(Income					NorthEast	2.73			
California West 2821 39,586,653 7.1 423,970 6.65 Di Colorado West 481 5607,154 8.6 269,827 1.76 Di Colorado Xuth 2.5 961,939 2.6 6.452 3.87 Di Delaware South 2.5 961,939 2.6 6.452 3.87 Di Delaware South 2.5 961,939 2.6 6.452 3.87 Di Delaware South 2.5 961,939 2.6 6.452 3.87 Di Delaware 739 3.1 153,909 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.12 2.14 1.00 1.00,000 persons 0.00	Difficing and contraction West 2821 39,58,653 7.1 428,970 6.65 Diff Colorado West 481 5,607,154 8.6 26,9837 1,78 Dif Colorado NorthEast 123 3,58,184 3.4 14,337 8.57 Dif Colorado South 2.5 961,939 2.6 6.452 3.87 Dif Colorado Population - 2017 - - - - - Dif Havaii Ara - square Im 538 6.9 28,311 3.500 2.12 Dif Indian Maxaii 943 3.9 216,632 0.31 - <td>@ Arkansas</td> <td>South</td> <td>55</td> <td>3,004,279</td> <td>1.8</td> <td>137,733</td> <td>0.40</td> <td></td> <td>2</td> <td>The second</td> <td></td> <td>4.74</td> <td></td> <td>Pacific</td> <td>6.78</td> <td>1</td> <td></td> <td></td>	@ Arkansas	South	55	3,004,279	1.8	137,733	0.40		2	The second		4.74		Pacific	6.78	1		
Cill Colorado West 481 5.607,154 8.6.2 269,837 1.78 Connecticut NorthEast 123 3.588,144 3.4.4 14,357 8.57 Cill Colorado Population - 2017 - 400 3.3 170,304 4.08 Connecticut 739 3.1 153,609 2.11 3.500 Di Hawaii Ara -ropars inn 538 6.9 2.8,311 3.500 Di Idaho 100,004 943 3.9 216,632 0.31 Di Illinois Abbrivition 0.23 4.5 149,998 3.881 Di Illinois Abbrivition 0.23 4.5 149,998 3.881 Di Illinois Abbrivition 0.23 4.5 149,998 3.881 Di Illinois Abbrivition 0.23 4.5 149,998 3.81 Di Illinois Abbrivition 0.23 4.5 149,998 3.81 Di Illinois Abbrivition 0.23 4.5 149,998 3.81 Di Illinois Abbrivition 0.23 1.8 10.5 0.61 Di Mary and 123 2.2 13,966 0.44 Di Mary and 907 2.2 91,646 0.33	Colorado West 4.81 5.607, 154 8.6 26.9, 837 1.78 Colorado West 123 3.588, 164 3.44 14,357 8.77 Colorado Valuation - 2017 -400 3.3 170,304 4.08 Cecorgia Population - 2017 -400 3.3 170,304 4.08 Colorado 739 3.1 153,909 2.12 Di Hawaii Ass-squere im 538 6.9 2.8311 3.50 Di Idaho 102.04 023 4.5 149,998 3.83 Di Idaho 102.34 818 3.3 9.421 2.24 Di Idaho 102.3 145,74 0.61 0.000 0.000 Di Kansas 186 donied 123 3.2 2.133 0.61 Di Cousiana 199 2.6 10.46,59 1.11 101 2.8 2.04,98 0.81 Di Maryland 907 2.2 9.19,646 0.33 0.61 9.99 1.31 1.35,98 9.99 Di Massachusets 819 0.	@ California	West	2821	39,536,653	7.1	423,970	6.65		T					South	2.69	2		
Connecticut NorthEast 123 3,588,184 3,4 14,357 8,57 Delaware South 25 961,999 2.6 6,452 3,87 Diptorida Population-2017 400 3,3 170,304 4,08 Diptorida Population-2017 739 3,1 155,909 2,12 Diptorida Ares-sigure km 538 6.9 28,311 3.50 Diptorida 102,34 943 3.9 216,632 0,31 Diptorida 102,34 943 3.9 216,632 0,31 Diptorida 102,34 943 3.9 216,632 0,31 Diptorida 102,34 943,21 2,24 0,61 0,659 0,41 Diptorida 155,030 189 2.6 104,659 1,11 0,659 1,11 Di Maine 907 2.2 1,81,64 0,26 0,23 1,81 1,83,542 0,26 Di Mainesota 1,900 1,11 12,8 2,21,33 8,00 0,27 1,33 1,00 1,31 <td>Connecticut Northeast 123 3,388 184 3,4 14,357 8,57 Delaware South 25 961,939 2,6 6,452 3,87 Difforda Population - 2017 - 400 3,3 170,304 4,08 Difforda Population - 2017 - 400 3,3 170,304 4,08 Difforda Population - 2017 - 400 3,3 170,304 4,08 Difforda Depulation - 2017 - 400 3,3 170,304 4,08 Difforda Depulation - 2017 - 400 3,3 170,304 4,08 Difforda Depulation - 2017 - 400 3,3 170,304 4,08 Difforda Difforda Population - 2017 - 400 3,3 170,304 4,08 Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda <thdifforda< th=""> Difforda Difforda</thdifforda<></td> <td>@Colorado</td> <td>West</td> <td>481</td> <td>5,607,154</td> <td>8.6</td> <td>269,837</td> <td>1.78</td> <td></td> <td>They want</td> <td></td> <td></td> <td>2.69</td> <td><u> </u></td> <td>West</td> <td>6.20</td> <td>)</td> <td></td> <td></td>	Connecticut Northeast 123 3,388 184 3,4 14,357 8,57 Delaware South 25 961,939 2,6 6,452 3,87 Difforda Population - 2017 - 400 3,3 170,304 4,08 Difforda Population - 2017 - 400 3,3 170,304 4,08 Difforda Population - 2017 - 400 3,3 170,304 4,08 Difforda Depulation - 2017 - 400 3,3 170,304 4,08 Difforda Depulation - 2017 - 400 3,3 170,304 4,08 Difforda Depulation - 2017 - 400 3,3 170,304 4,08 Difforda Difforda Population - 2017 - 400 3,3 170,304 4,08 Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda Difforda <thdifforda< th=""> Difforda Difforda</thdifforda<>	@Colorado	West	481	5,607,154	8.6	269,837	1.78		They want			2.69	<u> </u>	West	6.20)		
ID Delaware South 25 951,939 2.0 6.452 3.87 ID Florida Population: 2017 400 3.3 170,304 4.08 ID Hawaii Ane-squee km 538 6.9 28,311 3.50 ID Idaho 170,304 943 3.9 216,652 0.31 ID Ilininis Abservation 023 4.5 149,998 3.88 ID Indiana US-FL 618 3.3 94,321 2.34 ID lowa Data founded 711 2.8 145,743 0.61 ID Namice 189 2.6 104,659 1.11 0.4 ID Namice 907 2.2 16.66 0.33 1.03 ID Maine Population change (%) -2010,2016 177 4.2 32.138 8.00 ID Mainesota 7.30,494 - 952 3.3 2.666 0.33 1.03 1.04 1.05 1.04 1.04 1.03 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.04 <td>BD Pelaware By Florida Decorgia South 23 961,959 2.6 6.452 3.87 By Florida Decorgia Population 2017 2.600 3.3 170,304 4.06 By Florida 739 3.1 153,909 2.12 Decorgia 20.84,400 739 3.1 145,920 3.3 10.000 ag kilometers Decordia 711 2.8 145,743 0.61 0.000 persons 0.000 persons Minematic 907 2.2 91,646 0.33 1.01 0.000 persons 0.000 persons<</td> <td>@ Connecticut</td> <td>NorthEast</td> <td>123</td> <td>3,588,184</td> <td>3.4</td> <td>14,357</td> <td>8.57</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>Grand Total</td> <td>3.72</td> <td></td> <td></td> <td></td>	BD Pelaware By Florida Decorgia South 23 961,959 2.6 6.452 3.87 By Florida Decorgia Population 2017 2.600 3.3 170,304 4.06 By Florida 739 3.1 153,909 2.12 Decorgia 20.84,400 739 3.1 145,920 3.3 10.000 ag kilometers Decordia 711 2.8 145,743 0.61 0.000 persons 0.000 persons Minematic 907 2.2 91,646 0.33 1.01 0.000 persons 0.000 persons<	@ Connecticut	NorthEast	123	3,588,184	3.4	14,357	8.57							Grand Total	3.72			
Dipplation-2017 - 400 3.3 17.0,304 4.08 Cecorgia 23.94.400 739 3.1 15.30.909 2.12 DHawaii Ares-spare tim 53.8 6.9 28.311 3.50 D'Idaho 170.304 94.8 3.9 216.632 0.31 D'Ildaho 170.304 94.8 3.9 216.632 0.31 D'Ildaho 170.304 94.8 3.9 94.321 2.34 D'Ildaho 170.304 0.61 0.23 4.51 149.998 3.83 D'Ildaho 170.304 0.61 0.23 3.2 213.096 0.44 D'Il Cuisiana 123 3.2 213.906 0.44 0.44 0.459 1.11 D'Il Cuisiana Jacksonsite 907 2.2 91.646 0.33 0.000 0.91 0.000 get sons	Big Horida Population: 2017 2400 3.3 170,304 4.08 Correga 2094400 739 3.1 153,009 2.12 DHawaii Area -square km 538 6.9 28,311 3.50 D'Idaho 170,304 948 3.8 29,998 3.81 D'Illiniois 023 4.5 149,998 3.83 D'Illiniois 023 4.5 149,998 3.83 D'Illiniois 023 4.5 149,998 3.83 D'Illiniois 023 4.5 149,998 3.81 D'Illiniois 023 3.2 213,096 0.44 D'Exerruis 113 3.2 213,096 0.44 D'Exerruis 189 2.6 104,659 1.11 D'Illiniois 333 1.8 135,382 0.62 D'Illiniois 333 1.8 135,382 0.62 D'Illiniois 333 1.8 15,382 0.62 D'Illiniois 333 1.8 15,382 0.62 D'Illiniois 311 2.8 20,0498 1.13 D'Illiniois 311 2.8 2.04,048 1.13 D'Illiniois 36	Delaware	South	25	961,939	2.6	6,452	3.87	- 2	100				-					
R_berging 200 cold 7.99 3.1 153,509 2.12 Difficion 388 6.9 28,311 3.50 Difficionis Abbrivition 023 4.5 149,998 3.83 Difficionis Abbrivition 123 3.2 213,096 0.44 Difficionia Hayset difficion 133 1.8 3.5,382 0.661 Difficionian 149 907 2.2 91,646 0.33 Difficionian Abbrivition 177 4.2 2.7,336 9.99 Difficionian 7.00,64 - 952 3.3 2.25,181 0.82	A_berogragia below with the state of	dim Florida	Population - 20 30.984.400	17	- 400	3.3	170,304	4.08	-							_			
Di Harvail Area -square km 538 6.0% 26,811 5.00 Di Idaho 10,04 943 3.9 216,632 0.31 Di Ilinois Abbrevistion 023 4.5 149,998 3.83 Di Marsa 138 133 9.432.1 2.24 Di Kansas 1845-00-03 189 2.6 104,659 1.11 Di Manie 907 2.2 9.166 0.83 Di Marsachusetts 907 2.2 9.166 0.810 Di Massachusetts 819 4.0 27,336 9.999 Di Minnesota 7.00,424 9.52 3.3 2.5,181 0.26 Di Missispipi Powerd by ling (w) 100 1.1 125,443 0.26 Di Missouri 36 1.050,493 3.4 381,154 0.09 Di Missouri 36 1.050,493 3.4 381,154 0.09 Di Missouri 36 1.050,493 </td <td>MPHWall Ars-space km 538 0.9 223 1 3.00 Millinois Abbrevistion 023 4.5 149.998 3.83 Millinois Date founded 711 2.8 145.743 0.61 Millinois Lagest chy 333 1.8 155.822 0.62 Millinois Abstevistion 100 1.77 4.2 32.133 8.00 Millinois and Massachusetts 6% 819 4.0 27.336 9.99 1.13 3.4 3.9.21 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.</td> <td>A Seorgia</td> <td></td> <td></td> <td>/39</td> <td>5.1</td> <td>153,909</td> <td>2.12</td> <td>- 24</td> <td>1.</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-</td> <td></td> <td></td> <td></td>	MPHWall Ars-space km 538 0.9 223 1 3.00 Millinois Abbrevistion 023 4.5 149.998 3.83 Millinois Date founded 711 2.8 145.743 0.61 Millinois Lagest chy 333 1.8 155.822 0.62 Millinois Abstevistion 100 1.77 4.2 32.133 8.00 Millinois and Massachusetts 6% 819 4.0 27.336 9.99 1.13 3.4 3.9.21 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.9.2 1.	A Seorgia			/39	5.1	153,909	2.12	- 24	1.						-			
Direction 10,5x4 10,5x4 10,5x2 0.31 Difficiana USFR. 023 4.5 149,998 3.83 Difficiana USFR. 711 2.8 145,743 0.61 Difficiana 158,50-03 123 3.2 213,096 0.44 Difficiana 123 3.2 213,096 0.44 Difficiana 189 2.6 104,659 1.11 Difficiana 177 4.2 32,133 8.00 Difficiana 19 4.0 27,336 9.999 Difficiana 100 1.1 125,443 0.026 Difficiana 100 1.1 125,443 0.026 Difficiana 100 1.1	Dialogical Unique 943 3.3 210,822 0.31 Dialogical 023 4.5 149,998 8.83 Dialogical 033 143,998 8.83 Dialogical 034 149,998 8.83 Dialogical 034 111 2.8 145,743 0.61 Dialogical 123 3.2 213,096 0.44 Dialogical 123 3.2 213,382 0.62 Dialogical 907 2.2 91,646 0.33 DiMaryland Population change (%) - 2010, 2016 177 4.2 23,133 8.00 DiMissispipi Powered by Bing 100 1.1 2.6 250,493 1.13 DiMissispipi Powered by Bing 100 1.1 125,443 0.26	D Hawan	Area - square kr	m	538	0.9	28,311	3.50											
Abbreviation UC3 4-3 44-3	Durminols Abberviation 02.2 4.3 143/1996 3.04 Dilloriana US-FL 618 3.3 94,321 2.34 Dilloriana Lagest city 333 1.8 135,382 0.62 Dilloriana Lagest city 333 1.8 135,382 0.62 Dilloriana Develation change (N)-2010,2016 177 4.2 32,133 8.00 9.99 Dillorigian Households-2015 311 2.8 25,738 9.99 3.33 1.04 9.92 3.33 1.04 9.92 3.33 1.04 9.92 3.33 1.04 9.92 3.33 1.04 9.92 9.92 3.33 1.04 9.92 3.33 1.04 9.92 9.92 9.92 9.92 9.92 9.92 9.92 9.92 9.92 9.92 9.92	millinoic	170,304		945	5.9	210,032	0.51				-	and by thing					-+	
La michanda US-41 Oline 3-3-3 2-3-4 2-3-4 Coffee Shops per 100,000 persons Coffee Shops per 1,000 sq kilometers Di Kansas 1845-08-03 123 3.2 213,096 0.44 Di Kansas 189 2.6 104,659 1.11 Di Louisiana Jacksonville 907 2.2 91,646 0.33 Di Maryland Population change (%) - 2010, 2016 177 4.2 32,133 8.000 Di Minesota 7,00,494 - 952 3.3 225,181 0.82 Di Mississippi Powered by Bing (4) 100 1.11 125,443 0.26 Di Mississippi Powered by Bing (4) 100 1.11 125,443 0.26 Di Mississippi Powered by Bing (4) 100 1.11 125,443 0.26 Di Mississippi Powered by Bing (4) 100 1.11 1125,443 0.26 Di Mississippi Powered by Bing (4) 100 1.11 125,443 0.26 Di Missouri 36 1.050,493 3.4 381,154<	miniminalia 05-14 05-16 2.5-3 2.5-3 2.5-3 milowa 010 wa 010 wa 010 wa 0.5-14 2.5-3 2.5-3 milowa 010 wa 010 wa 010 wa 0.5-14 2.5-3 2.5-3 milowa 010 wa 010 wa 123 3.2 213,096 0.61 milowa 123 3.2 213,096 0.44 milowa 189 2.6 104,659 1.11 milowa 907 2.2 91,646 0.33 milowasschusetts 907 2.2 21,646 0.33 milowasschusetts 96% 819 4.0 27,336 9.99 milosissispipi Powerd by fling 100 1.1 125,443 0.26 milosissispipi Powerd by fling 100 1.1 125,443 0.26 milosissispipi Powerd by fling 100 1.1 125,443 0.09 milosissispipi Powerd by fling 100 1.1 125,443 0.09 milosissispipi Powerd by fling 100<	(Titediana	Abbreviation		010	4.5	04 221	2.05		1	1								
Date founded 111 2.0 140,743 0.01 Diff Kansas 1845-03-03 189 2.6 104,659 1.11 Di Louisiana Jastsomille 907 2.2 91,666 0.33 Di Marie Population change (%) - 2010, 2016 177 4.2 32,133 8.00 Di Marie 907 2.2 91,666 0.33 1.00 1.01 1.02,133 8.00 Di Marie 907 2.2 91,666 0.33 8.00 9.6% 907 2.2 91,666 0.33 Di Marie 90,04100n change (%) - 2010, 2016 177 4.2 32,133 8.00 9.6%	Date founded Date founded Da	(TILlowa	US-FL		711	2.9	145 742	0.61		Coffee Shop	s per 100,000	persons			Coffee Shops p	er 1,000 sq kilom	eters	-	
IBS-03-03 IBS-03-03 IBS-02-03 IBS-02-03 IBS-02-03 IDKentucky IBS-02-03 IBS-02-03 IBS-02-03 IDM IDLouisiana Jacksenville 907 2.2 91,666 0.33 IDMAryland Population change (%)-2010,2016 177 4.2 32,133 8.00 IDMAssachusetts 907 2.2 91,666 0.33 1.13 1.13 1.12 1.13	1845-03-03 163 2.6 104,659 1.11 ID Louisiana Jasksomkie 907 2.2 91,646 0.33 ID Marine Population change (%) - 2010, 2016 177 4.2 32,133 8.00 ID Massachusetts 64 19 4.0 27,336 9.999 1.11 ID Minnesota 7.30,494 - 952 3.3 2.5,181 0.82 ID Mississippi Powered by Bing 100 1.11 125,443 0.26 ID Mississippi Powered by Bing 100 1.11 125,443 0.26 ID Mississippi Powered by Bing 100 1.11 125,443 0.26 ID Mississippi Pivot Sheet Image: Pivot She	(III Kansas	Date founded		123	3.2	213.006	0.44										-	
Image: city Jacksonville 333 1.8 135,382 0.62 ID Maine 907 2.2 91,646 0.33 ID Maryland Population change (%) 2010, 2016 177 4.2 32,133 8.00 ID Michigan Households - 2015 311 2.6 250,493 1.13 ID Michigan Households - 2015 311 2.6 250,493 1.13 ID Mississippi Powered by Bing (m) 1.00 1.1 125,443 0.26 ID Michigan West 36 1.050,493 3.4 381,154 0.09 1.00 1.1 125,443 0.26 ID Michigan West 36 1.050,493 3.4 381,154 0.09 1.00 1.01 1.01 1.01 1.01 1.01 1.01 1.01 1.01 1.01 1.01 1.02 1.01 1.02 1.01 0.09 1.00 1.01 1.02 1.02 1.01 1.02 0.01 1.01 0.01 1.01 0.01 1.01 0.02 1.01 0.01 0.01 1.01 0.01	Lagest city Jacksomile Domisiana DMaryland Population change (%) - 2010, 2016 907 2.2 91,646 907 2.2 91,646 907 2.2 91,646 907 2.2 91,646 907 2.2 91,646 908 177 4.2 32,133 8.000 9.6% 819 4.0 27,336 9.999 DMichigan Households - 2015 111 2.8 250,493 1.13 DMinnesota DMississippi Pometed by Bing West 36 1.050,493 3.4 381,154 0.09 Coffee Shops Pivot Sheet (\bullet) $(\bullet$	(III Kentucky	1845-03-03		189	2.6	104 659	1.11						-					
Discretion Jacksonville Sol No No. No. ID Maine Population change (%) -2010, 2016 177 4.2 32, 133 8.00 ID Maine 96% 819 4.0 27,336 9.99 ID Minesota 7,300,494 - 952 3.3 225,181 0.82 ID Mississippi Powered by Bing (m) 1.0 1.1 125,443 0.26 ID Mintana West 36 1.050,493 3.14 8.1154 0.09 ID Montana West 36 1.050,493 3.4 381,154 0.09 ID Montana West 36 1.050,493 3.4 381,154 0.09 ID Montana West 36 1.050,493 3.4 381,154 0.09	Image: Construint Jacksonville 907 2.2 91,646 0.033 Image: Construint 819 4.0 27,336 9.999 Image: Construint 911 2.8 250,493 1.13 Image: Construint 952 3.3 225,181 0.822 Image: Construint 992 3.3 225,181 0.822 Image: Construint 993 3.4 381,154 0.09 Image: Construint 993 993 1.1 1.1 1.1 1.1 Image: Construint 9100 1.1 <t< td=""><td>mLouisiana</td><td>Largest city</td><td></td><td>333</td><td>1.8</td><td>135 382</td><td>0.62</td><td>50.2</td><td>1</td><td>the second second</td><td></td><td>4.</td><td>M</td><td>0.09</td><td>8.07</td><td></td><td>6</td><td></td></t<>	mLouisiana	Largest city		333	1.8	135 382	0.62	50.2	1	the second second		4.	M	0.09	8.07		6	
IDMaryland Population change (%) - 2010, 2016 177 4.2 32,133 8.00 IDMaryland Population change (%) - 2010, 2016 177 4.2 32,133 8.00 IDMarsland Households - 2015 311 2.8 250,493 1.13 IDMinesota 7.300,694 - 952 3.3 225,181 0.82 IDMississippi Powered by Bing (a) 1.00 1.1 125,443 0.26 IDMissouri result all of the state	III Maryland 9.6% Population change (%) - 2010, 2016 9.6% 177 4.2 32,133 8.00 III Massachusetts 9.6% Households - 2015 311 2.8 250,493 1.13 III Minesota - 952 3.3 225,181 0.82 III Mississippi Powerd by Bing Households - 2015 311 2.8 250,493 1.13 III Mississippi Powerd by Bing Households - 2010 11 125,443 0.26 III Mississippi Powerd by Bing Households - 2010 3.1 127,243 0.26 III Mississippi Powerd by Bing Households - 2010 3.4 381,154 0.09 III Mississippi Powerd by Bing Households - 2010 3.4 381,154 0.09 III Mississippi Pivot Sheet III 2.4 3.4 381,154 0.09 III Mississippi Pivot Sheet III IIII 2.4 3.4 381,154 0.09 III Mississippi Pivot Sheet IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	00 Maine	Jacksonville		907	2.2	91.646	0.33		1. 14	u	the second	all	LA	0.31	0.13 0.85	-2-		
96% 819 4.0 27,336 9.99 ID Missachusetts 111 2.8 250,493 1.13 ID Minnesota 7,30,644 - 952 3.3 225,181 0.82 ID Mississippi Powered by ling (w) 100 1.1 125,443 0.26 ID Monana West 36 1.050,493 3.4 381,154 0.09 ID Monana ID Monana ID Monana ID Monana ID Monana ID Monana ID Monana<	Image: marging field 819 4.0 27,336 9.99 Image: marging field 952 3.3 225,181 0.82 Image: marging field 100 1.1 125,443 0.26 Image: marging field 100 1.1 125,443 0.09 Image: marging field 100 1.1 125,443 0.09 Image: marging field 100 1.1 125,443 0.09 Image: marging field 100 1.1 100,533 1.04 Image: marging field 100 1.1 100,533 1.04 Image: marging field 100 1.1 100,533 100 Image: marging field 100 1.05,0493 3.4	@ Maryland	Population cha	nge (%) - 2010, 2016	177	4.2	32,133	8.00		4.0	2.5 2.	2. 2.8	10 -		0.09	0.29 0.61	2.00 5		
Image: Display interview Households - 2015 311 2.8 250,493 1.13 Image: Display interview - 952 3.3 225,181 0.82 Image: Display interview - 952 3.3 25,181 0.82 Image: Display interview - 952 3.1 180,533 1.04 Image: Display interview - 96 - 96 - 96 - 96 Image: Display interview - 96 - 96 - 96 - 96 Image: Display interview - 96 - 96 - 96 - 96 Image: Display interview - 96 - 96 - 96 - 96	III Michigan Households - 2015 311 2.8 250,493 1.13 III Minnesota 7,30,494 - 952 3.3 225,181 0.82 III Mississispipi Powered by Bing 100 1.1 125,443 0.26 III Montana West 36 1.050,493 3.4 381,154 0.09 Vest 36 1.050,493 3.4 381,154 0.09 14 13 14 Vest 36 1.050,493 3.4 381,154 0.09 14 15 16 Vest 36 1.050,493 3.4 381,154 0.09 14 16 16 Vest 36 1.050,493 3.4 381,154 0.09 14 16 16 Vest 36 1.050,493 3.4 381,154 0.09 16 16 16 17 16 17 17 16 17 17 18 18 18 19 16 16 16 16 16 16 16 16 16 16 16	@ Massachusetts	9.6%		819	4.0	27.336	9,99		11	3.0 2.4	11 12	100		0.46 1.78	0.44 1.04	8.90		
Implininesota 7,300,494 -952 3,3 225,181 0.82 Implininesota 7,00,494 -952 3,3 225,181 0.82 Implinississippi Powered by Bing 100 1,1 125,443 0.26 Implinissouri virunesa 0,00 1,1 125,443 0.26 Implinissouri virunesa 0,00 1,1 125,443 0.09 Implinissouri virunesa 0,00 3,4 381,154 0.09 Implinissouri Virunesa 0,00 1,00 1,00 Implinissouri Virunesa 0,00 1,00 Implinissouri 0,00 1,00 1,00 Implinissouri Virunesa 0,00 Implinissouri Virunesa 0,00 Implinissouri Implinissouri 0,00 Implinissouri Implinistouri Implinistouri Implinistouri Implinistouri Implinistouri Implinistouri 3,4 3,1 Implinistouri Implinistouri Implinistouri Implinistouri Implinistouri Implinistouri Implinistouri Implinistouri Implinistouri Implinistouri Implinit <td>Implementation 7,300,494 - 952 3.3 225,181 0.82 Implementation 100 1.1 125,443 0.26 Implementation </td> <td>@ Michigan</td> <td>Households - 20</td> <td>015</td> <td>311</td> <td>2.8</td> <td>250,493</td> <td>1.13</td> <td></td> <td></td> <td>12 11</td> <td>2.6 -</td> <td>1</td> <td></td> <td>100</td> <td>0.44</td> <td>2.42</td> <td></td> <td></td>	Implementation 7,300,494 - 952 3.3 225,181 0.82 Implementation 100 1.1 125,443 0.26 Implementation	@ Michigan	Households - 20	015	311	2.8	250,493	1.13			12 11	2.6 -	1		100	0.44	2.42		
Implementation Powered by Bing Implementation 1.1 125,443 0.26 Implementation V, r.v., 532 3.1 180,533 1.04 Implementation West 36 1.050.493 3.4 381.154 0.09 Implementation Privot Sheet Implementation Implementation Implementation Implementation Implementation West 36 1.050.493 3.4 381.154 0.09 Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation <td< td=""><td>Implementation Powered by Bing Implementation 1.1 125,443 0.26 Implementation Implementation Implementation Implementation Implementation Implementation West 36 1.050,493 3.4 381.154 0.09 Implementation Implementation Implementation Implementation Implementation Implementation Implementation West 36 1.050,493 3.4 381.154 0.09 Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation <td>@ Minnesota</td><td>7,300,494</td><td></td><td>- 952</td><td>3.3</td><td>225,181</td><td>0.82</td><td></td><td>10 16</td><td>2.0 1.8</td><td>2.7</td><td>2.6</td><td></td><td>6.34</td><td>0.360.63</td><td>2.3.2</td><td></td><td></td></td></td<>	Implementation Powered by Bing Implementation 1.1 125,443 0.26 Implementation Implementation Implementation Implementation Implementation Implementation West 36 1.050,493 3.4 381.154 0.09 Implementation Implementation Implementation Implementation Implementation Implementation Implementation West 36 1.050,493 3.4 381.154 0.09 Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation <td>@ Minnesota</td> <td>7,300,494</td> <td></td> <td>- 952</td> <td>3.3</td> <td>225,181</td> <td>0.82</td> <td></td> <td>10 16</td> <td>2.0 1.8</td> <td>2.7</td> <td>2.6</td> <td></td> <td>6.34</td> <td>0.360.63</td> <td>2.3.2</td> <td></td> <td></td>	@ Minnesota	7,300,494		- 952	3.3	225,181	0.82		10 16	2.0 1.8	2.7	2.6		6.34	0.360.63	2.3.2		
Impose Non-state	Importere of pany Importered of pany	@ Mississippi	Description of the Description		no n 100	1.1	125,443	0.26			17	13 27 81	1			130 0_			
Importana West 36 1.050.493 3.4 381.154 0.09 Importance Importance<	Implementation West 36 1.050.493 3.4 381.154 0.09 Implementation <	@ Missouri	Fowered by bing	100	0,110,532	3.1	180,533	1.04	- S		- H	1.000	13	1 9	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	N. Contraction			
Coffee Shops Pivot Sheet Image: Coffee Shops ady Image: Image: Coffee Shops Image: Imag	Coffee Shops Pivot Sheet ⊕ ⋮ øy III III III III	D Montana	West	36	1.050.493	3.4	381.154	0.09	7	4 6			1	1					_
¢ه الله الله الله الله الله الله الله ال	øy tal	Co Co	ffee Shops	Pivot Sheet	(+)						3 4]
		adv til			122.1										EB	岡 四	1.1		+ 70
		ady 🔝													H		-		+

Ignite 2018

С	D	E	F	G	Н	
🕽 Gloria's Food	🕅 Daily Goals					
MondayMotivation eeping up with my nutrition oals = #livingmybestlife	32.1%	24.4%	46.6%	0		
	Calories	Carbohydrates	Fat			
Today	641.4 cal	61.1g	23.3g			
Goal	2000	250	50			-
/ly food 🎙						
od 👻	calories 🚽	carbohydrates 🖵 fa	at 👻			
) chicken breast	110.04	1.00	2.29			_
) boiled egg (1 serving)	210.80	1.52	14.43			
) strawberry (4 items)	15.10	3.78	0.10			
) banana (1 item)	105.02	26.95	0.39			-
) oatmeal cookie (2 items)	134.10	19.92	5.37			
	00.34	1.54	0.75			



Starting today, the LET function is available to Excel users in the Insiders Ring to preview. The LET function allows you to define and use formula scoped names. Calculating a weighted average: =LET(values,A1:A4, weights,B1:B4, SUM(values*weights)/SUM(weights)) 💡

 \sim

6:16 PM · Mar 17, 2020 · Twitter Web App

28 Retweets 93 Likes

٢	David Benaim N Replying to @jjn Let it be!	AVP @DaveBenaim ncdaid	· Ma	Bre	? Jkj
	\Diamond		♡ 3	/Ver	
	Exceljet @excelj Replying to @jjn Excellent. This w operation more	et · Mar 17 ncdaid ill really streamline o than 1x.	certain formulas th	at require the sa	me
	\Diamond	Ĺ.↓	♡ 2	ſ	
Ţ	Ryan Bond @Ry Replying to @jjn This is similar to	/NBond · Mar 17 ncdaid 'With' in Power App	15		~
	\heartsuit	1.J	♡ 1	\triangle	
<u>رچ</u>	Ed Hansberry @ Replying to @jjn Now we just nee #PowerBI and #F	ehansalytics · Mar ncdaid d to be able to form owerApps	18 nat formulas easie	r in Excel like we	∽ can in
	\Diamond	Ĺ.↓	♡ 1	≏	
-	Abiola David I Replying to @jjn Really cool funct	Excel MVP 🚺 🍣 🦞 ncdaid ion	28 @AbiolaDavi	d01 · Mar 17	~
	Q 1	Ĺ	♡ 1	\triangle	
	Reagan Onyang Now even befor	o @rigs12 · 18h e I breathe xlookup,	the real bomb is ł	nere!	~
	\Diamond	t.	\bigcirc	≏	
	Oz du Soleil @0 Replying to @jjn So cool!	DzExcel · Mar 18 ncdaid			~
	\heartsuit	17	\odot	企	

Calculation View

What if we offered a code-centric view of the grid?

Microsoft Research

	<mark>ਗ</mark> ੀ ਹੈੱਟ ਟੋਂ ਵ					Small.xlsx - Ex	cel				Neil Toronto 🗠 – 🗅 🗙
Fi	ile Home Insert Draw	Page Layout Formulas	Data Revi	riew View De	eveloper Ad	d-ins LOAD	TEST Team	🖓 Tell me w	vhat you want to	do	우 Share 🙂
f. Ins Func	Ex Sert ction AutoSum Recently Financial Logical Used	A Text Date & Lookup & Math & Time τ Reference τ Trig τ Library	More Functions - M	C Define Nar C Define Nar C Use in Form Manager Create from Defined Names	ne ▼ Bin T nula ▼ o⊈ T n Selection F s	ïrace Precedents ïrace Dependents Remove Arrows ★ For	Show Formul. ・ Error Checkin ⑥ Evaluate Form mula Auditing	as g Vatch Window	Calculation Calculation	Calculate Now Calculate Sheet lation	~
De	preciation \cdot : $ imes$ \checkmark f_x	=99%									~
	A	В	С	D	E	F	G	Н	I	J	Calculation View • ×
1	Depreciation	99%		HoldingCost	0.10%	, 					
2	Assets	Present value	2019	2020	2021	2022	2023	2024	2025	2026	
3	Terminal with Electronic Components	£ 2,728.17	£ 2,698.16	£ 2,668.48	£ 2,639.13	£ 2,610.10	£ 2,581.39	£ 2,552.99	£ 2,524.91	£ 2,497 👘 (Ctrl)	Depreciation B1=99%
4	Accessories Others	£ 196.77	£ 194.61	£ 192.46	£ 190.35	£ 188.25	£ 186.18	£ 184.14	£ 182.11	£ 180.11 £	HoldingCost 51-0 1%
5	Accessories SAK	£ 10.32	£ 10.21	£ 10.09	£ 9.98	£ 9.87	£ 9.76	£ 9.66	£ 9.55	£ 9.45 £	
6 7	Accessories SAK	£ 38.28	£ 37.86	£ 37.44	£ 37.03	± 36.62	£ 36.22	£ 35.82	± 35,43	£ 35.04 £	C3:N1002=B3*Depreciation-(B3*HoldingCost)
7 8	SAK-Series	£ 500.00 f 430.48	f 425.7	1 - 380.37			f 40782	FV4CU	398.41	f 394.02 f	TotalPresentValue Q3=SUM(C3:C1002)
9	SAK-Series	£ 731.01	£ 722.97		F 107 15	699.37	£ 691.68	£ 684.07	£ 676.55	£ 669.10 £	TotalEndValue Q4=SUM(N3:N1002)
10	SAK-Series	£ 423.61	£ 418.95	£ 414.34	£ 409.78	£ 405.28	£ 400.82	£ 396.41	£ <u>3</u> 92.05	£ 387.74 £	TotalLoss Q5=TotalPresentValue-TotalEndValue
11	SAK-Series	£ 397.49	£ 393.12	£ 388.79	£ 384.52	£ 380.29	£ 376.10	£ 37.97	C 57.87	£ 363.83 £	
12	SAK-Series	£ 321.88	£ 318.34	£ 314.84	£ 311.17	A ().95	£ .56	2 30: 2:	3 1.0	£ 294.62 £	
13	SAK-Series	£ 660.61	£ 6 <mark>53.3</mark> 4		6:9.5	02 02		£ 618.19	£ 611.39	£ 604.67 £	
14	SAK-Series	£ 748.58	£ 7 <mark>40.35</mark>	£ 732.20	£ 724.15	£ 716.18	£ 708.30	£ 7).51	£ 692.81	£ 685.19 £	
15	Coupler	£ 53.97	£ 53.38	£ 52.79	£ 52.21	£ 51.63	£ 51.07	£ 5しつ	£ 49.95	£ 49.40 £	_
16	SAK-Series	£ 356.36	£ 352.44	£ 348.56	£ 344.73	£ 340.94	£ 337.19	£ 333.48	329.81	£ 326.18 £	
17	SAK-Series	£ 362.18	£ 358.20	£ 354.26	£ 350.36	£ 346.51	£ 342.69	£ 338.92	£ = 20	£ 331.51 £	
18	Coupler	£ 49.81	£ 49.26	£ 48.72	£ 48.18	£ 47.65	£ 47.13	£ 46.61	£ 46.10	I 45.55 I	
19	SAK-Series	£ 229.38	£ 226.86	£ 224.36	£ 221.89	£ 219.45	£ 217.04	£ 214.65	£ 212.29	£ 209.95 £	-
20	SAK-Series	£ 155.25	£ 153.54	£ 151.85	£ 150.18	£ 148.53	£ 146.90	£ 145.28	£ 143.68	£ 142.10 £	-
21	SAK-Series	£ 130.88	£ 129.44	£ 128.02	£ 126.61	£ 125.22	£ 123.84	£ 122.48	£ 121.13	£ 119.80 £	-
22	SAK-Series	£ 130.88	£ 129.44	£ 128.02	£ 126.61	£ 125.22	£ 123.84	£ 122.48	£ 121.13	£ 119.80 £	-
23	SAK-Series	£ 139.52	£ 137.99	£ 136.47	£ 134.97	£ 133.48	£ 132.01	£ 130.56	£ 129.13	£ 127.70 £	_
24	SAK-Series	£ 144.00	£ 142.42	£ 140.85	£ 139.30	£ 137.77	£ 136.25	£ 134.75	£ 133.27	£ 131.81 £	-
25	Accessories SAK	£ 37.59	£ 37.18	£ 36.77	£ 36.36	£ 35.96	£ 35.57	£ 35.18	£ 34.79	£ 34.41 £	-
26	Accessories Others	£ 3.16	£ 3.13	£ 3.09	£ 3.06	£ 3.02	£ 2.99	£ 2.96	£ 2.92	£ 2.89 £	_
27	Accessories Others	£ 1.91	£ 1.89	£ 1.87	£ 1.85	£ 1.83	£ 1.81	£ 1.79	£ 1.77	£ 1.75 £	-
28	Accessories SAK	£ 38.21	£ 37.79	£ 37.37	£ 36.96	£ 36.56	£ 36.15	£ 35.76	£ 35.36	£ 34.97 £	-
29	Accessories SAK	£ 34.69	£ 34.31	£ 33.93	£ 33.56	£ 33.19	£ 32.82	£ 32.46	£ 32.11	£ 31.75 £	-
30	Accessories SAK	£ 34.69	£ 34.31	£ 33.93	£ 33.56	£ 33.19	£ 32.82	£ 32.46	£ 32.11	£ 31.75 £	-
24		0.070			0 05 50		C 04 74	c	c	C 22 C4 C	

	ਰੀ ਨੈਂਟਟੱਟ ਤੋ			Small.xlsx - Exce	el		Neil Toronto 🖾 — 🗅 🗙
Fi	ile Home Insert Draw	Page Layout Formulas Data	Review View Developer	Add-ins LOAD T	EST Team 🖓 Tell me w	hat you want to do	A Share 🙂
f	γ Σ 🖈 🖃 2		👝 🖙 Define Name 🔻	and the second	5 Show Formulas	Calculate Now	
J.			🖌 Use in Formula 🕶	□ 🖧 Trace Dependents	♦ Error Checking ▼		
Func	ction - Used	 Time - Reference - Trig - Functions - 	Manager 🔐 Create from Selection	n 🛱 Remove Arrows 🔻	(*) Evaluate Formula Window	Options -	
	Function	Library	Defined Names	Form	nula Auditing	Calculation	A
C3	• : × ✓ fx	=B3*Depreciation-(B3*HoldingCost)					v
		be bepreciation (be fieldingeout)					
	A	B C	D E	F	G H		Calculation View - ×
1	Depreciation	99%	HoldingCost	0.10%			
1 2	Assets	Procent value 20	10 2020	2021 2022	2022 2024	2025 2026	✓ Show Formulas Only
2	Assets	Present value 20		2021 2022	2023 2024		
3	Terminal with Electronic Components	£ 2,728.17 £ 2,698.	.16 £ 2,668.48 £ 2,6	39.13 £ 2,610.10	£ 2,581.39 £ 2,552.99	£ 2,524.91 £ 2,497.13 £ 2	Derreciation R1=99%
4 c	Accessories Others	$\frac{1}{2}$ 190.77 \pm 194.	01 E 192.46 E 1	90.35 £ 188.25	t 180.18 t thige	.ost et - 0.1%	
5	Accessories SAK	$\frac{2}{5}$ 10.32 E 10.	21 E 10.09 E	9.90 E 9.07			
7	Accessories SAN	£ 388.88 £ 384	60 f 380 37 f 3	76 19 £ 372 05	C3·N1002	=B3*Depreciation	n-(B3*HoldingCost)
8	SAK-Series	$f = \frac{43048}{43048} f = 425$	$74 f 42106 f 4^{\circ}$	16.43 £ 411.85	f	bo Depreciatio	in (bo Holdingcost)
9	SAK-Series	$f = \frac{73101}{1000000000000000000000000000000000$.97 £ 715.02 £ 7	07.15 £ 699.37	f 691.68 f 684.07		1/02 01000 ·······························
10	SAK-Series	£ 423.61 £ 418.	.95 £ 414.34 £ 40	09.78 £ 405.28	£ 400.82 £ 396.41	£ 392.05 £ 387.74	Totall oss $0.5 = TotalPresentValue-TotalEndValue$
11	SAK-Series	£ 397.49 £ 393.	.12 £ 388.79 £ 38	84.52 £ 380.29	£ 376.10 £ 371.97	£ 367.87 £ 363.8 £	
12	SAK-Series	£ 30 32188 £ 218.	34 £ 314.84 £ 31	11.37 £ 307.95	£ 304.56 £ 301.21	£ 297.90 £ 2°,62 £	
13	SAK-Series	£ aled	51 £ 646.16 £ 63	39.05 £ 632.02	£ 625.07 £ 618.19	£ 611.39 £ 604.67 £	
14	SAK-Series	£ 748.58 £ 740.	Urmila	24.15 £ 716.18	£ 708.30 £ 700.51	£ 692.81 £ 685.19 £	
15	Coupler	f COp 53.97 f 53.	38 £ 5501d		£ 51.07 £ 50.50	£ 49,5 £ 49.40 £	
16	SAK-Series	£ CODV/nac	44 £ 348.56 £ 34	44.73	£ 337.19 £ 333.48	£ 29.81 £ 326.18 £	
17	SAK-Series	£		50.36 £ 340.31	2 342.69 £ 338.92	335.20 £ 331.51 £	
18	Coupler	£ 3 r 49.81 £ 49.			£ 47.13 £ 46.61	£ 46.10 £ 45.59 £	
19	SAK-Series	E UIE group	.86 £ 224.36 £ 2.	"ag-ri	217.04 214.65	£ 212.29 £ 209.95 £	
20	SAK-Series			50.18 £ 148.53	E 12690 145.28	£ 143.68 £ 142.10 £	
21	SAK-Series			26.61 ± 125.22	£ 123.84 £ 122.48	£ 121.13 £ 119.80 £	
22	SAK-Series	VIEWAd	$44 \pm 128.02 \pm 12$	udn h	\pm 123.84 \pm 122.48	£ 121.13 £ 119.80 £	
25 24	SAK-Series			20.20 £ 127.77	£ 136.25 £ 134.75	E 129.13 E 127.70 E	
24 25	Accessories SAK	f = 37.59 + 37	'Y CUITA	3 36 2 35 96	f 35.57 f 35.18	f 34.79 f 34.41 f	
26	Accessories Others	$\frac{2}{f}$ 316 f 3	13 f 3.09 f	1 dS nr	1 - 2.99 + 2.96	f = 2.92 f = 2.89 f	
27	Accessories Others	£ 1.91 £ 1.	.89 £ 1.87 £	1.85 £ 1.83	f C1.81 f 1.79	£ 1.77 £ 1.75 £	
28	Accessories SAK	£ 38.21 £ 37.	.79 £ 37.37 £	36.96 £ 36.56	£ 36.15 £ 35.76	£ 35.36 £ 34.97 £	
29	Accessories SAK	£ 34.69 £ 34.	31 £ 33.93 £	33.56 £ 33.19	£ 32.82 £ 32.46	£ 32.11 £ 31.75 £	
30	Accessories SAK	£ 34.69 £ 34.	.31 £ 33.93 £	33.56 £ 33.19	£ 32.82 £ 32.46	£ 32.11 £ 31.75 £	
~ 4	1 0.11	0 00.70 0 00				a aa aa a aa aa a	

	• ې ، ک														Sn	nall.xlsx - Ex	cel			Neil Toronto 🗇 – 🗇 🗙	
File	Home		nsert	Draw	Page	Layout	Form	mulas Da [.]	ta	Review	Viev	w De	veloper	r Ac	ld-ins	s LOAD	TEST Tea	am Ç) Tell me v	what you want to do A Share 😁	
fx	Σ	*	000	?	Α		٩	θ			⊡D	efine Nam	ie 👻	랆~	Trace	e Precedents	😼 Show For	rmulas		Calculate Now	
Incort	AutoSum	Pacan	thy Einancia		cal Taxt	Data & L		& Math &	Moro	Namo	∱x U	lse in Form	ula 👻	-27	Trace	e Dependents	s 🐪 Error Che	ecking 👻	Watch		
Functior	Autosum	Used		ai Logi •		Time - Re	eference	e ▼ Trig ▼ Fur	nctior	ns - Manage	r 🔐 Ci	reate from	Select	ion 🔀	Remo	ove Arrows 🔻	🕼 Evaluate	Formula	Window	Options →	
				Fund	ction Library	/		5		5	Defir	ned Names				Fo	rmula Auditing	I		Calculation	ŀ
TotalL	oss 👻	:	× v	f_X	=Tota	alPresent	tValue-	-TotalEndVal	ue											· · · · · · · · · · · · · · · · · · ·	
	F		G		н	I		J		к		L		М		N	0		Р		
																				Timulas Only	
1																				onnulus only	
2	2022	2	2023		2024	2	2025	2026	5	2027		2028		2029		2030					
3 £	2,610.10	£ 2	2,581.39	£ 2	,552.99	£ 2,52	4.91	£ 2,497.13	£	2,469.67	£2,	,442.50	£ 2,4	415.63	£	2,389.06		Total	presep*		
4 £	188.25	£	186.18	£	184.14	£ 18	32.11	£ 180.11	£	178.13	£	176.17	£	174.23	£	172.31		Total	valv	Depreciation B1=99%	
5 £	9.87	£	9.76	£	9.66	£	9.55	£ 9.45	£	9.34	£	9.24	£	9.14	£	9.04		Total	10		
6 £	36.62	£	36.22	£	35.82	£ 3	5.43	£ 35.04	£	34.65	£	34.27	£	33.89	£	33.52		/	/	HoldingCost E1=0.1%	
7 £	372.05	£	367.96	£	363.91	£ 35	9.91	£ 355.95	£	352.03	£	348.16	£	344.33	£	340.54				5	
8 £	411.85	£	407.32	f.	402.84	£ 39	8.41	£ 394.02	£	389.69	£	385.40	£	38116	£	376.97				C3:N1002 = B3*Depreciation-(B3*HoldingCost)	
9 £	699.37	£	691.68	FT	68,07	ea	5		£	nari	n	2 .46	HC	5472S	£	and		51	-		
10 £	405.28	£	400.82	£	396.41	£ 39	2.05	É 387.74	£	383.47	£	379.25	£	375.08	£	370.96				TotalPresentValue Q3=SUM(C3:C1002)	
11 £	380.29	£	376.10	£	371.97	£ 36	57.87	£ 363.83	£	359.83	£	355.87	£	351.95	£	348.08			-		
12 ±	307.95	£	304.56	n	an	ne	S	$\pm 294 - 2$	Ο	rm	±	lae		285.01	£	281.87				TotalEndValue O4=SUM(N3:N1002)	
15 E	716 19	L L	709.20	<u>د</u>	700 51	1 60	1.59	L 695 10	L	677.65	<u>د</u>	670.10	L I	204.95 662.92	L L	655 52					
14 L 15 f	51 63	L L	51.07	L.	50.51	£ /	10 05	f 10 10	L L	C 18.86	۲ ۲	/8.32	E I	Λ7 7Q	£	/7.26				Totall oss 05=TotalPresentValue-	
16 f	340.94	f	337.10	- -	high	r	6.2	IKAS	т Г	tor	m	R19 14	a	A r	Υ	nor				Total Loss Q5 - Total Tesentvalue	
10 L 17 £	346.51	£	342.69	f	338.92	£ 33	5.20	£ 331.51	£	327.86	£	324.26	f	320.69	£	317.16				TotalEndValue	
18 £	47.65	£	47.13	£	46.61	£ 4	6.10	£ 45.59	£	45.09	£	44.59	£	44.10	£	43.62			1		
19 £	219.45	£	217.04	re	22	da	b	A 209.95	£	207.65	£	205.36	£	203.10	£	200.87					
20 £	148.53	£	146.90	£	145.28	£ 14	3.68	£ 142.10	£	140.54	£	138.99	£	137.46	£	135.95					
21 £	125.22	£	123.84	£	122.48	£ 12	1.13	£ 119.80	£	118.48	£	117.18	£	115.89	£	114.61					
22 £	125.22	£	123.84	£	122.48	£ 12	1.13	£ 119.80	£	118.48	£	117.18	£	115.89	£	114.61					
23 £	133.48	£	132.01	£	130.56	£ 12	9.13	£ 127.70	£	126.30	£	124.91	£	123.54	£	122.18					
24 £	137.77	£	136.25	£	134.75	£ 13	3.27	£ 131.81	£	130.36	£	128.92	£	127.50	£	126.10					
25 £	35.96	£	35.57	£	35.18	£ 3	84.79	£ 34.41	£	34.03	£	33.65	£	33.28	£	32.92					
26 £	3.02	£	2.99	£	2.96	£	2.92	£ 2.89	£	2.86	£	2.83	£	2.80	£	2.77					
27 £	1.83	£	1.81	£	1.79	£	1.77	£ 1.75	£	1.73	£	1.71	£	1.69	£	1.67					
28 £	36.56	£	36.15	£	35.76	£ 3	85.36	£ 34.97	£	34.59	£	34.21	£	33.83	£	33.46					
29 £	33.19	£	32.82	£	32.46	£ 3	32.11	£ 31.75	£	31.40	£	31.06	£	30.72	£	30.38					
30 £	33.19	£	32.82	£	32.46	£ 3	32.11	£ 31.75	£	31.40	£	31.06	£	30.72	£	30.38					

A	utoSave On 🔍	<u>ि</u> छ		€ ~ ₹		l	Experiment da	ta v2 (final).x	lsx - Last	Saved 11/	10/2018 15:39	1 -	Advait Sarkar	• -	- 🗆	×
Fil	e Home	Insert	Draw	Page Layout	Formulas	Data Revi	ew View	Add-ins	Help	Team	,⊂ Tell	me what you want to do			ය Share	IJ
		_														
T26	0 -	\times	√ f;													`
	Α	в	L C	D	EF	G	н	1	J	к	L					
1	Participa – First (condition	🝷 Task '	1 c 🗝 Task 1 i 🔫 1	ask 2 🗾 Task	2 🛨 Task 3 🛨	Task 3 🗾 Ta	sk 4 💼 Tasl	k 4 📼 Se	con 🗝 Ta	sk 5 c 🛨 Tas	calculation-view			-	×
2	1 Norm	al		W1A 158	W2A 283	D1A	63	D2A 77	Ca	lc Viev	W1B 104	calculation-view				
3	2 Norm	al Li:		W1B 170	W2B 182	D1B	246	D2B 122	Ca	Ic Viev	W1A 60			7		
9 5	3 Laic 4 Cale	View		WZA 200 W2B 313	WIA 00	D2A	125	D18 100	No No	rmai rmal	W2D 235	🔰 🕹 🦊 🗸 🗸 🗸 🗸 🗸 🗸 🗸 🗸 🗸	🖉 🔎 Search	🗋 🕐 Ref	fresh	
6	5 Norm	al		W1A 172	W2A 129	D1A	262	24 C	-18		W1B_61			_		
7	6 Norm	al		W1B 512	W2B 215	D1B	223	D B 10	l (a	id V S	W1A 45	K	"Normal", "Cal	c View"."N	Vormal")	
8	7 Cale	View		W2A 400	W1A 68	D2A	160 🤳	A 124	No	rmal	W2B 307	🚽 🚽 🔄 Sort Descending			,	
9	8 Calc	Vie v		W2B 144	W1B 64	D2B	58	D1B 52	No	rmal	W2A 102					
10	9 Norm	al		W1A_164	W2A_110	D1A	70	D2A 110	Ca	lc Viev	W1B_59	H Sort by:				
11	10 Norm	al		W1B 193	W2B 287	D1B	75	D2B 59	Ca	lc Viev	W1A 120	K				
12	11 Cale	Vie v		W2A 240	W1A 120	DZA	83	D1A 23	No	rmal	W2B 266	🕂 💀 Row wise				
13	12 Uale 1	View		W2B 178	W1B 38	U2B	27	U1B 14	No	rmal	W2A 163		ormal])*100			
14	13 Norm	al		WIA 450	WZA 337 U2R 134	DIA	334	D28 55	La	lo Viev la Viev	V10 68	K 📧 Column wise				
16	15 Cale	ai View		W10 13	W1A 50	D10	50	D1A 44	No	rmal	W2B 175					
17	16 Cale	View		W2B 88	W1B 44	D2R	24	D1B 53	No	rmal	W2A 202	📙 📙 Formula length				
18	17 Norm	al		W1A 69	W2A 60	D1A	54	D2A 32	Ca	lc View	W1B 27	K				
19	18 Norm	al		W1B 341	W2B 388	D1B	72	D2B 22	Ca	lc View	W1A 62	↓ ↓ Alphabetical				
20	19 Cale	View		W2A 80	W1A 72	D2A	27	D1A 26	No	rmal	W2B 428		_			
21	20 Cale	Viev		W2B 64	W1B 48	D2B	22	D1B 44	No	rmal	W2A 181	T206:U206=MEDIAN(T184:T2	205)			
22	21 Norm	al		W1A 157	W2A 222	D1A	68	D2A_38	Ca	lc Viev	W1B 52	AB206:AC206=MEDIAN(AB1	84:AB205)			
23	22 Norm	al 		W1B 375	W2B 408	D1B	63	D2B 33	Ca	lc Vien	W1A 60					
24	23 Cale 1	View		W2A	W1A	U2A D2D		DIA	No	rmal	W2B	K222=MEDIAN([Difference])				
20	24 Laic	VIEW		W2D	WID	U2B		UIB	No	rmal	WZH	L222=MEDIAN([Difference %	5])			
20												C229/D316=LOG10(F229)				
28													171			
29												1248:0248=MEDIAN(1226:17	247)			
30	Minut	es	- Seco	nc	Partic	cir – Task oc –	Task ty 📕 No	rmal <u>-</u> CV	- Dif	fere – Dif	feren -	AB248:AC248=MEDIAN(AB2	26:AB247)			
33			3	240		102		77	180	-30	-133.77					
37			7	420		2 01	n	246	90	156	63.41					
38			8	480		2 D2	D	122	67	55	45.08					
41						3 D2	D	54	219	-165	-305.56					
42						3 D1	D	65	78	-13	-20.00					
45						4 D2	D	300	125	175	58.33					
46						4 D1		143	100	43	30.07					
49						5 01		182	53	179	67.52					
53						6.01	n	223	48	125	78.48					
54						6 D2	D	40	20	20	50.00					
57						7 D2	D	136	160	-24	-17.65					
58						7 D1	D	178	124	54	30.34					
61						8 D2	D	24	58	-34	-141.67					

Auto	Save On 🔍	18 D		🔏 👻 🔻			Experir	ment data v2	t (final).xls	sx - Last Si	aved 11/10	0/2018 15:39 👻		Advait Sarkar	Τ.	- U	×
File	Home	Insert	Draw	Page Layout	Formulas	Data	Review	View A	Add-ins	Help	Team		e what you want to do			🖄 Share	5
												·					Ŭ
T260	· · · ·	×	√ _f:	×													~
	•	R	L C		F	G			1 .	I I K							
1 Part	icipa <mark>n First</mark> o	condition	Task	1 🗧 Task 1 🗧 T	ask 2 🔽 Task	2 - Task	3 🔽 Task	3 🝷 Task 4	Task	4 - Seco	n – Tasl	5 c - Tas	colculation view			-	×
2	1 Norma	al		W1A 158	W2A 283		D1A		02A 77	Calc	Viev	W1B 104	calculation-view				~
3	2 Norma 3 Colo V	al View		W1B 170	W2B 182		D1B 2	Or i	10,78	Calc	Viev	W1A 60					
5	4 Calc	View		W2B 313	V/18 31		D2B 125		48 100		al	W2A 185	↓= Sort ∨ Y Filter ∨	Search	OI	Refresh	
6	5 Norma	al		W1A 172	V2A 12		D1A 262)2A 182	Cale	Viev	W1B 61					
7	6 Norma	al		W1B 512	W2B C 5		D1B 223		02B 40	Calc	Viev	W1A 45	K2:K25=IF([@[First condition]]	="Normal","Ca	lc View"	,"Normal")	
8	7 Cale	View		W2A 400	W1A B)rr	m		D1A 124	Norm	al	W2B 307	L31:L118=([@Difference]/[@N	lormal])*100			
9	3 Norma	view		W2B 144	W16 04			ЛА		Norm		WZA 102	1222-MEDIAN/(Difference %))			
10	10 Norma	al		W1B 193	W2B 287		D1B 75	A I G	12B 9	Cac	ØТ	120		,			
12	11 Cale 1	View		W2A 240	W1A 120		D2A 83	[D1A 23	Norn		W28 266	L1/1=MEDIAN([Difference %])			
13	12 Calc 1	Viev		W2B 178	W1B 38		D2B 27	[D1B 14	Norm	al	W2A 163	L119=MEDIAN([Difference %])			
14	13 Norma 14 Norma	al əl		W1A 450	W2A 337		D18 120		JZA 83 128 55	Calc	View	V18 103	K222=MEDIAN([Difference])				
16	15 Cale	ai Vie v		W2A 110	W1A 50		D2A 50		D1A 44	Norm	al	W2B 175	K171-MEDIAN([Difference])				
17	16 Cale ^y	Viev		W2B 88	W1B 44		D2B 24	[D1B 53	Norm	al	W2A 202	KT/T=MEDIAN([Difference])				
18	17 Norma	al		W1A 69	W2A 60		D1A 54		02A 32	Calc	Viet	W1B_27	K119=MEDIAN([Difference])				
19	18 Norma 19 Colo 1	al u:		W1B 341	W2B 388		D1B 72		2B 22	Calc	Viev	W1A 62	AB248:AC248=MEDIAN(AB22	6:AB247)			
20	20 Cale 1	view View		W2A 60 W2B 64	WIA (2 W1B 48		D28 27		DIA 20 DIB 44	Norm	al	W2B 420	AB206:AC206=MEDIAN(AB18	4:AB205)			
22	21 Norma	al		W1A 157	W2A 222		D1A 68)2A 38	Calc	Viet	W1B 52	T249-U248-MEDIAN/T226-T24				
23	22 Norm	al		W1B 375	W2B 408		D1B 63		02B 33	Calc	Viet	W1A 60	1240:0240=MEDIAN(1220:124	+/)			
24	23 Calc	View		W2A	W1A		D2A	[D1A	Norm	al	W2B	T206:U206=MEDIAN(T184:T20)5)			
25	24 Calc	Viev		W2B	WIB		U2B		JIB	Norm	al	WZA	K31:K118=[@Normal]-[@CV]				
26													C31:C40=[@Minutes]*60				
28																	
29									011	Deff	D+//		C229:D316=LOG10(F229)				
30	Minut	es	- Seco	180	Part	CIPT Task (1 D1	cq≖ Task ⊓	ty 🖬 Normal	- LV 63	Tet Uiffe	-98 Uilfe	155 56	H31:H118=LEFT(G31,1)				
34			4	240		1 D2	D		77	180	-103 -	133.77					
37			7	420		2 D1	D	2	246	90	156	63.41					
38			8	480		2 D2	D	·	122	67	55	45.08					
41						3 D2			54 65	78	-105 -	-20.00					
45						4 D2	D	3	300	125	175	58.33					
46						4 D1	D		143	100	43	30.07					
49						5 D1	D	2	262	83	179	68.32					
53						5 D2 6 D1	D		182	48	123	78.48					
54						6 D2	D	2	40	20	20	50.00					
57						7 D2	D		136	160	-24	-17.65					
58						7 D1	D		178	124	54	30.34					
61						8 D2	D		24	58	-34	-141.67					

A	utoSave 🔘 🔍	े क		🧏 ~ 🔻		Expe	riment data v2 (fin	al).xlsx - L	ast Saved 11/	/10/2018 15:39	*	Advait Sarkar [五 一	
Fil	e Home	Insert	Draw	Page Layout	Formulas	Data Review	View Add-	ins He	lp Team	n ,⊅ Tell n	me what you want to do		ır Lei s	hare 🕤
		_												
T26	i0 🔻	\times	√	*										
	A	в	L C	D	E F	G	н і	J	к	L				
1	Participa <mark>-</mark> First	condition	📑 Task	1 c 🕶 Task 1 i 🖛 1	Fask 2 🔁 Task 2	💌 Task 3 💌 Tas	ik 3 💌 Task 4 💌 🕯	Task 4 💻	Secon 🔫 Ta	sk 5 c 👻 Tas		liow		- X
2	1 Norm	al		W1A 158	W2A 283	D1A 63	D2A T	77	Calc View	W1B 104		1evv		
3	2 Norm	al V:		W1B 170	W2B 182	D1B 246	D2B	72	Laic Viev	W1A 60				
9 5	3 Calc	View		W2R 250	WIA 00	DZA 213		100	Normal	W2B 235	ļ ↓ F Sort ∨ `	🍸 Filter 🗸 🔎 Search	🔿 Refresh	
6	5 Norm	al		W1A 172	V/2A 129	E 8 26		182	Calc Viev	W1B 61				
7	6 Norm	al		W1B 512	W2B 215	L 18 22	HPr	In	a Vier	W1A 45	K2:K25=IF([@[F		al	")
8	7 Calc	View		W2A 400	W1A-68	D2A 160			annal	W2B 307	121/1119-/(@D	 Formulas only 		-
9	8 Calc	Viev		W2B 144	W1B 64	D2B 58	D1B 5	52	Normal	W2A 102	LS1:L110=([@D			
10	9 Norm	al		W1A 164	W2A 110	D1A 70	DZA	110 1	Calc Viev	W1B 59	L222=MEDIAN(Values only		
11	10 Norm	al		W1B 193	W2B 287	D1B 75	D2B S	59	Calc View	W1A 120	1171=MEDIAN(
12	11 Uale	View		W2A 24U	W1A 120	UZA 83	U1A 2	23	Normal	W2B 266		Named items only		
13	12 Laic	View		W2B 178	WIB 38	D10, 294	DIB	14	Normal	WZA 163	L119=MEDIAN(
19	13 Norm	ai		WIA 450	W2A 337	DIA 334	DZA C	55	Calc View	V1A 68	K222=MEDIAN	Precedents and Depen	dents >	
16	15 Cale	View		W2A 110	W1A 50	D2A 50	D1A 4	44	Normal	W2B 175	K171-MEDIAN			
17	16 Calc	View		W2B 88	W1B 44	D2B 24	D1B S	53	Normal	W2A 202	KT/T=IVIEDIAIN	🔽 Clear Filters		
18	17 Norm	al		W1A 69	W2A 60	D1A 54	D2A S	32 1	Calc Viev	W1B 27	K119=MEDIANtru	/merencej/		
19	18 Norm	al		W1B 341	W2B 388	D1B 72	D2B 2	22	Calc Viev	W1A 62	AB2//8-AC2//8-M	EDIAN(AB226-AB247)		
20	19 Calc	View		W2A 80	W1A_72	D2A 27	D1A 2	26	Normal	W2B_428	7.0240.AC240-M			
21	20 Calc	View		W2B 64	W1B 48	D2B 22	D1B 4	44	Normal	W2A 181	AB206:AC206=M	EDIAN(AB184:AB205)		
22	21 Norm	al		W1A 157	W2A 222	D1A 68	D2A C	38	Calc Viev	W1B 52	T248:U248=MED	IAN(T226:T247)		
23	22 Norm	al		W1B 375	W2B 408	D1B 63	D2B C	33	Calc View	W1A 60	T205-U205-MED			
24	23 Laic	View		WZA U2P	UIA UID	D2R	DIA		Normal	W2B	1206:0206=MED	IAIN(1184:1205)		
20	24 Calc	view		w2D	WID	020	DID		Normai	WZM	K31:K118=[@Nor	mal]-[@CV]		
20											C31:C40-[@Min	ites]*60		
28											co ne40-[@wind	nesj oo		
29											C229:D316=LOG	10(F229)		
30	Minut	tes	🚽 Seco	nc 🕋	Partici	ir 🕋 Task oc 🕋 Tas	ik ty 🔳 Normal 💌 (CV 👱	Differe 🔫 Dif	feren 🛫	H31:H118=LEFT(G31.1)		
33			3	180		1 D1 D	63	161	-98	-155.56				
34			4	240		102 0	77	180	-103	-133.77				
37			8	420		2 02 0	240	50 67	100	45.08				
41			-	400		3 D2 D	54	219	-165	-305.56				
42						3 D1 D	65	78	-13	-20.00				
45						4 D2 D	300	125	175	58.33				
46						4 D1 D	143	100	43	30.07				
49						5 D1 D	262	83	179	68.32				
50						5 D2 D	182	59	123	67.58				
53						6 D1 D	223	48	1/5	78.48				
57						7 02 0	40	160	-24	-17.65				
58						7 D1 D	178	124	54	30.34				
61						8 D2 D	24	58	-34	-141.67				

	AutoSav	e On 🌒	ି ଭ) ~	° 🕰 👻 👘	Ŧ	Experir	nent data v	2 (final).xlsx	: - Saved	to OneDriv	ve - Microso	ft -	Table To	ools	Advait Sarkar 🖻 —		×
F	ïle	Home	Insert	Draw	Page L	.ayout	Formulas	Data	Review	View	Add-i	ins Help	o Team	n Desig	jn	ho Tell me what you want to do	🖻 Share	IJ
E3	6	-	: ×	~ j	fæ =R	9-E9												~
														1				
	A	В	С		E	F	G H	1	J	К	E M	N	\sim (Q				
1	Norma	- 01 -	02 -	02 - 0			De - 07	- ne -	09 0 0	0 - 0	- L	c 2				calculation-view	*	×
2	Partici	1	2 0	3	4 4		7	5 4	GO M G		4	50	5	3	911			_
4		2	6 0	6	4		7	5C	0		5.1	2	4	0		↓= Sort ∨ ▼ Filter ∨ 🔎 Search 🕐 Refr	esh	
5		3	97	7	7	8	Dr	PU	EL	n 7	7.5	3	7	2				
5		4	7 4 3 3	4	7	8	8			8	7.3	4	łC	10	1	Precedents (current sheet only):		
8		6	5 6	5	8	7	7	7 6	6	6		on	LJ	5		Y3:Y24=AVERAGE(Table5[@[Q1]:[Q10]])		
9		7	8 5	7	7	8	8.5 8	8.5 8					9	3		13:124-AVEPAGE(Table57[@[01]:[010]])		
10		8	8 5	6	8	10	7	AC	ונאכ		7.2	8	8	5		L3.L24=AVERAGE(Table37[@[QT].[QT0]])		
11		9 10	7 U 9 2	5	7	8			- M	- 7	7.2	10	9	2				
13		11	8 4	8	8	9	9	10 7	10	10	8.3	11	6	3				
14		12	96	10	9	10	10	9 10	10	9	9.2	12	7	6	1	Grid selection:		
15		13	1 0	2	1	2		0 1	2	3	1.3	13	4	0		B30:L51=O3-B3		
16		14	9 3 E 4	8	10	9	9	10 9	10	9	8.6	14	6	2				
17		15 16	5 4 7 7	ر 4	8	10	9	9 7	10	ر 8	7.9	15	7	7	-			
19		17 1	0 6	8	5	10	10	10 7	10	10	8.6	17	10	7		Dependents (surrent sheet enhilt		
20		18	2 3	6	10	10	9	8 7	9	9	7.3	18	2	3		Dependents (current sneet only):		
21		19	7 0	7	8	0	8	7 5	8	8	5.8	19	4	0		O44=E36		
22		20	5 2	8	8	10	10	8 8	10	8	7.7	20	5	2				
23		21 22	7 3 3 1	(ر 5	10	10	o o 4 10	8	8	62	21	3	1				
25			<u> </u>			10	10	4 10			0.2				-			
26																		
27																		
28	Differe	nce (CV -	Normal),	higher is	better													
29	Partici	• Q1 •	Q2 •	Q3 💌 G	94 💌 QS	5 💌 (26 💌 Q7	▼ Q8 ▼	Q9 💌 Q1	10 💌 Ave	er. 🔻	Question			-			
30		1	3 3	3	1	-2	0	0 1	3	2	1.4	1	if there was	s no one arour	n¢ Ju			
31		3 -	2 -5	-2	-1	-4	-2	-5 0	-2	0	-2.1	3	if Loplu bed	er used a paol I the manual fo	or Or			
33		4 -	3 -2	1	-1	2	1	-5 0	1	0	-0.6	4	if I had see	n someone els	se			
34		5	77	6	3	2	2	7 7	2	2	4.5	5	if I could ca	all someone fo	or			
35		6	5 -1	2	-1	0	0	1 1	0	2	0.9	6	if someone	else had help	pe			
36		7	1 -2	-2	1	1	0.5 0).5 1	0.5	1	0.25	7	if I had a lot	t of time to con	mj i			
37		б 9	υ Ü 1 0	U 3	-1	0	1	0 0	1	1	0.3	8	it i had only if comecone	the built-in he	el oc			
39		10	0 0	1	1	0	1	0 1	0	-1	0.3	10	if I had use	d similar packa	a			
40		11 -	2 -1		1	0	0	0 0	-1	-7	-1				1			
41		12 -	2 0	0	0	0	0	0 0	0	-1	-0.3							
42		13	3 0	1	2	0	2	2 2	3	0	1.5				_			
43		14 -	ა -1 -1 ი	0	0	0	0	0 -1	0	0	-0.5		1		-			
45		16	0 0	0	0	0	0	0 0	0	0	0.2		1					

4	AutoSave On 🔍	19 D	~ C ~ {	Ľ × ₹		Experir	ment data	a v2 (final).xlsx	- Saved to Or	neDrive - Micro	osoft 🝷	Advait Sarkar 🛛 🛣	- 0	×
Fi	ile Home	Insert	Draw	Page Layout	Formulas Data	a Review	View	Add-ins	Help T	ieam 🔎 1	fell me what you want to do		🖻 Share	I
Н6	2 👻 :	×	✓ f _x	-7.666666	66666667									v
	•			<u> </u>	D	r		6						
	A	Б		C	U	E	F	6	н	I Col			-	×
1	Normal	tal daman	v Dhusies	I daman y 170	6	rid			KO	Cal				
2	Participar • Men	tal deman	Physical 18		nporal Dema		- 6	Wd				$r \sim 9$ H15 \times ()	Refresh	
4	2	1	19	10	11	13	16	16	14.17				Refresh	
5	3		3	16	7	3	4	7	6.67		S	earch Results for: H15		
6	4	1	15	7	16		16		12.83		H3:H24=AVERAGE(Table	4[@[Mental demand]:[Frus	tration]])	
7	5	1	12	10	18	SE	C	19	15.67		· · · ·			
8	6		5	2	2			14	7.00					
9	7	1	11	2	11	4	11	7	7.67					
10	8	1	1	6	10	2	11	2	6.33					
12	10	1	4		18	4	15	2	5.50					
13	11	1	12	1	4	4	11	6	6.33					
14	12	1	15	2	1	4	10	2	5.67					
15	13	1	15	3	11	8	15	14	11.00					
16	14		7	1	3	3	8	2	4.00					
17	15		4	2	5	5	5	2	3.83					
18	16	1	14	10	3	6	11	9	8.83					
19	17		3	1	5	1	2	6	3.00					
20	18	1	13	4	4	13	16	12	10.33					
21	19		2	2	2	8	6	6	4.33					
22	20	1	17	1	11	6	16	6	9.50					
23	21	1	13	11	13	17	11	11	0.17					
24	22	د	14	1	1	1/		11	9.17					
26											-			
27	Difference (C	V - norn	nal), lov	ver is bette	r									
28	Participar J Men	tal deman	Physical	l deman 💌 Ter	mporal Deman 🔻 Pe	rformanc 🔻 F	ffort 🔻 E	rustratio 🔻 A	verage 🔻					
29	1	-1	L4	0	-8	-3	-2	-2	-4.83					
30	2		-9	1	-3	-6	-7	-6	-5.00					
31	3		3	-1	-2	2	4	-3	0.50					
34	6		-3	0	0	-8	-5	-12	-4.67					
38	10		3	0	-11	5	-1	0	-0.67					
41	13		-8	-1	-2	0	-4	-6	-3.50					
46	18		-4	-2	-1	-2	-6	-6	-3.50					

Studying calculation view

Authoring & debugging

- 20 participants, variety of backgrounds & expertise
- Improvement in task time and cognitive load





Comprehension

- 14 participants, spreadsheet comprehension test
- Improvement in comprehension and cognitive load in half the participants



Longitudinal deployment

• 7 MVPs, using CV for day to day work, ongoing reporting back

• Many uses, most positive feedback around auditing and comprehension

MVP feedback

• Solves the problem that formula view is aimed at

 P6: "[The current show formulas feature] is useless to me. [...] One of the most particular things that accountants do is get column size exactly right. And I need to see what the numbers are. I'm going to say words I've never said before. I like the fact that [Calc View] is in a task pane. That makes me feel dirty inside. But I love that I don't have to manipulate the sheet to flip it into formula view. Don't have to flip the grid. You guys are absolutely on the right track."

Very helpful for auditing and debugging

- P17: "Calc View has already been extremely useful to me in identifying spurious formulae, no longer needed, and the situation where not all formulae in a row had been amended to the newer [...] version. Calc View is already a winner!!"
- P9: 'Just plain text search is really good."
- P6: "Cool to have name, location and formula in one place. Formula evaluation tool is kind of weak. Calc View is a logical place to enable stepping from one thing to another. Maybe don't want to make calc view as rich as formula bar. Maybe just need a quick way to get to the formula bar."

Calculation View: multiple-representation editing in spreadsheets

Advait Sarkar*, Andrew D. Gordon^{*†}, Simon Peyton Jones*, Neil Toronto* *Microsoft Research, 21 Station Road, Cambridge, United Kingdom [†]University of Edinburgh School of Informatics, 10 Crichton Street, Edinburgh, United Kingdom {advait,adg,simonpj,netoront}@microsoft.com

- Results from over a year of testing, across three studies, with ~40 total participants from a diverse range of backgrounds.
- A powerful successor to 'show formulas'.

Calculation View helps people author, debug, and comprehend their spreadsheets.

Elastic Sheet-Defined Functions

Generalising Spreadsheet Functions to Variable-Size Input Arrays

Microsoft Research

Sheet defined functions

Peyton Jones, S.L., Blackwell, A.F., Burnett, M.M.: A user-centred approach to functions in Excel. ICFP 165–176 (2003)



	А	В	С	D	Е	F			
1	Averag	e functi	ion						
2									
3	Input:	4		Count:	5	=COUNT(B3:B7)			
4		5		Sum:	42	=SUM(B3:B7)			
5		23		Average:	8.4	=E4/E3			
6		4							
7		6							

```
In CalcView:

function AVERAGE( B3:B7 ) returns E5 {

E3 = COUNT( B3:B7 )

E4 = SUM( B3:B7 )

E5 = E4/E3
```

	А	В	С	D	Е	F				
1	Averag	e functi	ion							
2										
3	Input:	4		Count:	5	=COUNT(B3:B7)				
4		5		Sum:	42	=SUM(B3:B7)				
5		23		Average:	8.4	=E4/E3				
6		4								
7		6								

In CalcView:

```
function AVERAGE( B3:B7 ) returns E5 {
E3 = COUNT( B3:B7 )
E4 = SUM( B3:B7 )
E5 = E4/E3
```

Problem:

- =AVERAGE(X5:X7) too small!
- =AVERAGE(G2:G200) too big!

Solution:

• Somehow generalize what the user wrote

	А	В	С	D	Е	F		
1	Averag	e functi	ion					
2								
3	Input:	4		Count:	5	=COUNT(B3:B7)		
4		5		Sum:	42	=SUM(B3:B7)		
5		23		Average:	8.4	=E4/E3		
6		4						
7		6						

```
function AVERAGE( B3:B7 ) returns
E5 {
E3 = COUNT( B3:B7 )
E4 = SUM( B3:B7 )
E5 = E4/E3
```

function AVERAGE< α >(B3:B{3+ α }) returns E5 { E3 = COUNT(B3:B{3+ α }) E4 = SUM(B3:B{3+ α }) E5 = E4/E3 }

	А	В	С	D	Е	F
1	Averag	e functi	ion			
2						
3	Input:	4		Count:	5	=COUNT(B3:B7)
4		5		Sum:	42	=SUM(B3:B7)
5		23		Average:	8.4	=E4/E3
6		4				
7		6				

```
function AVERAGE<\alpha>(B3:B{3+\alpha}) returns
E5 {
```

- $E3 = COUNT(B3:B\{3+\alpha\})$
- $E4 = SUM(B3:B\{3+\alpha\})$
- E5 = E4/E3

Elastic SDF can be called with any $\alpha \ge 0$

- =AVERAGE(G2:G200)
- Figure out α = 198 from the arguments
- Instantiate the SDF sheet with α = 198
- Calc it
- Return the result
- Discard the instantiated sheet

TIMESHEET															
	First na	Last na	Catego	Rate	Date	01/04/2017	02/04/2017	03/04/2017	04/04/2017	05/04/2017	******	******	Total hours	Payment	
	John	Wire	Full-Time	20		0	0	4	8	0	4	0	16	320	
\$	Sophie	Gallaghe	Contract	25		0	0	0	0	8	8	4	20	500	
													Total to be pai	820	
Γ															
1															

First na	Last na	Catego	Rate	Date	01/08/2017	02/08/2017	03/08/2017	04/08/2017	05/08/2017	******	******	08/08/2017	******	*******	11/08/2017	*******	*******	14/08/2017	Total hours	Payment
David	Green	Full-Time	20		0	0	3	0	0	5	0	9	4	0	0	5	0	0		
Sarah	Jones	Full-Time	20		5	7	8	9	0	5	5	10	0	0	4	4	4	4		
Edward	Muller	Contract	25		0	0	0	0	0	8	10	0	5	0	0	8	0	0		
Hannah	Kirk	Part-Tim	15		8	0	0	4	0	8	4	0	3	5	3	0	8	8		
Jo	Carter	Contract	25		8	8	8	8	8	0	0	8	8	8	9	0	8	0		
Max	Wells	Full-Time	20		8	0	0	0	8	8	8	8	0	0	0	8	8	8		
																			Total to be p	3:S18))

=*E*(PAYMENT(D13:D18,F13:S18))

User's eye view

- \cdot Write a function with fixed-size inputs, using familiar copy/paste
- · Magic happens
- \cdot The function works on input of arbitrary size

Main point:we think that automatically inferred elasticity will
dramatically broaden the audience
that can use SDFs effectively.

The magic

- \cdot It really is quite amazing to
 - · Take a single, concrete function working on fixed size inputs
 - $\cdot \,$ And generalise it to arbitrary size inputs
 - \cdot In a predictable way
- \cdot But we can do it.
- We can even prove that the generalisation we find is the "best generalisation" in a very precise sense. Not just a set of heuristics.

Findings from user study (N=20, 7 female)

People perceived **significantly lower cognitive workload** for elastic SDFs than with SDFs based on map/reduce.

I think elastic functions are easier to work with, also with the "mental model" that you have of Excel, because you can more just follow your normal Excel **workflow**. – P9

It'd be nice to have this kind of **middle ground**, of not having to write the same things over and over again, but not having to persuade someone to make a macro either. – P7

Elastic Sheet-Defined Functions

Automatic generalization of map/reduce programs from example

Theorem: Elasticization yields most general generalization User study: Easier for end-users than map/reduce programs

Elastic Sheet-Defined Functions: Generalising Spreadsheet Functions to Variable-Size Input Arrays*

Matt McCutchen[†] Massachusetts Institute of Technology Cambridge, US matt@mattmccutchen.net

Judith Borghouts[†] University College London London, UK judith.borghouts.14@ucl.ac.uk Andrew D. Gordon Microsoft Research Cambridge, UK University of Edinburgh Edinburgh, UK adg@microsoft.com

Simon Peyton Jones Microsoft Research Cambridge, UK simonpj@microsoft.com Advait Sarkar Microsoft Research Cambridge, UK advait@microsoft.com





Remove the "glass ceiling" that limits the scope and reach of what a domain expert can do with Excel:

 Make Excel functions reflect the abstractions of our end users, by allowing end-users to define new functions using an ordinary worksheet.

 Make Excel's data values reflect the datatypes of our end users' domains, by adding arrays, vectors, records, and even domainspecific data types implemented by third parties.

Yellow Related Links

aka.ms/CalcIntel

Dynamic Arrays and New Functions in Excel! - Office Insider Blog

Video tour of Microsoft Research Cambridge

(gif2xlsx: Convert GIFs to XLSX format)

Microsoft Research