08 Visual Encoding

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http://info-design-lab.github.io

Visualization helps humans solve analytical problems quickly and accurately

Over-the-Counter

National Market System

The companies listed below reflect the volume in 100's of shares on a daily basis and the closing price and net change are reflected from the previous day based on trades as provided under the NASD National Market System.

Stock		Sales	Close	Chg.
—A—				
A&W Bd		51	28¾	−¼
ABSs	.32	2	6½	....
ACC Cp	.16	228	8¾	....
ADC		594	21¼	+⅛
ADT		993	31¾	+½
AEL		13	5¼	−½
AEPs		14	15¼	−¼
ALCh		256	⅞	+⅛
ASK		66	8⅞	+⅛
AST		2141	15¼	+⅝
AbingB	.16	3	5¾	....
AbeLinc		10	7	....
Acadin		75	31/32	−1/32
Aclaims		911	6⅝	−⅛
AclwtB		952	19/32	+3/32
Acelo	.14	2	14¾	+¾
ACMT		14	12½	+½
AcmeSt		177	15½	+½
ActARt		156	6½	−¼
ActnSv	.32	232	5¾	+¼
ActAuSt		30	2½	+⅛
Acxiom		21	21½	....
AdacLb	.16	1994	2 9/16	+1/16
Adage		408	1 5/16	....
Adapt		870	19	−⅛
Adingt s		2	16	+½
AdiaSv	.14	7	23¼	−¼
AdobeS	.20	4616	29⅝	+⅞
Adtec		779	2 1/16	−1/16
AdvCir s		578	7⅛	−¼
AdvRos		2	9½	+⅛
AdvMag		5	13	+¼
AdMkSv		22	6⅛	−⅛
AdvPoly		415	5¾	−¼
AdvTel		192	13½	+¼
Advanta	.13	571	9	+⅝
AdvoSy		127	9	....
Aequitrn		104	2⅛	....
Aegon	1.39	53	54¾	−¼
AerSysl		41	⅞	−1/16
Aerovx		1019	4⅜	+⅞
AflBcCp	.32	15	4⅜	+⅛
AflBsh		602	10⅞	−¼
AgncyR		589	12⅛	....
Agnico g	.20	122	9⅜	−⅛
AirMd		306	4	....
AirWisc		174	8⅞	−⅝
Airtran	.16	338	7⅛	....
Akorn	.07	129	1 9/16	−⅛
Akzo	1.46	450	31	+⅝
AlamBc	.60	24	25¼	+¼
Alaten	1.10	3	11⅛	−⅛
Aldus		916	20½	+½
AlexBr	.22	5	10¾	+¼
AlexBld	.80	3174	30	+½
AlfaCp	.36	26	9¾	−½
Alico	.20	12	29½	+½
AllAm s		40	1 9/16	+⅛
AlegW		634	10⅛	+⅞
AlianPh		216	9¼	+⅝
Alliant		1136	6¾	....
AlldCap	1.15	14	18	....
AldCall	.16	235	15	−⅛
AlldGp	.44	1	13	+¾
AlldRsh		9	2⅛	....
AllstFn		2	7⅜	−½
Allwst s		3166	9¼	....
Aloette	.32	755	15½	....
Alpharl		31	3/16	−⅛
AlpMic		25	3⅜	....
AltaGld	.06	1104	5 5/16	−3/16
Altera		4295	9¼	+½
Altus		5	1⅛	−¼
Altos		406	5	−¼
Altron		10	5	....
AmcorF	.50	20	15½	+¼
Amrian	.40	1	12	....
Amerbc	.22	50	6¼	....
AFFMI2	2.54	101	8¾	+½
AutoInf		229	4¾	....
AutoSy		30	2¼	....
Avntek		4759	2¼	....
Avatar		7	22¼	+½
Avndle	.92	432	8⅝	−¼
Aztar		3208	5¾	+⅛
AztcM	.10	45	5⅝	+⅛
—B—				
BB&T s	.80	53	18⅛	−⅜
BH Bulk	2.16	58	5	+⅛
BEI El	.06	x566	6⅜	....
BEI		5	2½	−⅛
BF Ent		2	6¾	....
BFS NY		17	9½	−½
BHAs		168	16¼	+¼
BHAB s		1629	15⅞	−⅛
BMA	1.20	x594	40½	+2¼
BMC Sft		189	30¼	−¼
BMJ	.60	10	14	....
BNH	.24	18	6¼	....
BSB Bcp	.60	3	18¼	....
BT Shp		567	13¾	−¼
BTU Int		339	3¾	−⅛
Babage		1304	4¾	−⅛
Badger	.48	2	20¾	+1¼
BakerJ	.06	5062	14⅛	+½
BldLyB	.30	450	20¼	....
BaldPia		178	6⅜	−¼
Balard	.10	71	20½	+¼
Baltek	.15	122	7¼	−¼
BncPnc	1.60	241	47	+¾
BnPop s	.80	20	19¾	+½
BcpHws	1.56	126	51	−¾
BcMiss	.84	5	20¼	−¾
Banctec		1636	18⅜	+½
BandoM	.88	30	8½	−¼
BangH	1.24	31	16	....
BankAtl		3	6¼	+¼
BkGrn s	.40	6	22	....
BnkNH	.92	28	13¾	−½
BkSou	.48	156	10¾	+⅛
Bnkest		144	1⅞	....
BnkFst	.28	16	6	−¼
BkrNte		42	2½	....
Bknth	1.08	2	16⅜	+⅛
BkIowa	1.00	7	72½	....
BkMAm		89	11¼	+⅛
BkWorc	.25	1089	16½	−¾
Banta	.56	33	22½	....
BaretRs		114	6½	....
BsTnA		4	2⅜	−3/16
BasAm		5	3⅜	−⅛
BasPtr s		57	10½	+½
BsetF	1.00	29	35	+¼
BayVw	.30	12	18⅜	+⅜
BayBks	1.80	502	23½	+½
BeauC s	.15	77	14¾	−½
BeautL		47	1¾	....
Beebas	.20	10	10⅞	−⅛
BelFuse		80	3¾	....
BellW		5	4¼	....
BellSv		160	4	....
BenJer		52	13½	+¼
Benhan		110	2⅛	....
Berkley	.40	219	36	+⅛
BerkGs	1.28	1	16½	+1
BethlBc	.57	30	11½	+¼
BetzLb	1.88	199	58	+1
Big B	.16	159	13⅛	+¼
BigOTr		34	1 7/16	+⅛
Bindly		3	9⅞	−⅛
BingKg		5	2¼	−½
Biogn wt		2	7	+¼
BiMedc		346	12⅞	+⅜
Biogen		1388	14⅝	−¼
Biogn pf	2.12	231	28½	−¼
Biomet s		1011	21	+½
BiotcR		65	3⅞	+⅛
BioTInt		40	4⅞	....
BizMrt		292	10¼	....
CapSw	1.44	2	22	+½
CapBcp		26	3½	−¼
CapTr s	.27	10	21	+1
CapCrb		70	3/16	....
CrdnlD s	.08	322	21¼	+¼
CarePls		189	11	+¼
CreP wtA		27	1 17/32	+5/32
CarlCm	.30	398	24⅞	−⅜
Carmik		32	12¼	....
Caringtn		652	24½	+1
Carver		86	4⅞	....
Cascde s	.60	55	17½	+⅜
CascInt		262	2 9/16	+¼
Caseys		8	9⅜	....
CastlEn	.06	73	9¾	+¼
CasiMie		148	2⅜	....
CaloCp	.08	80	2½	−¼
Celgene		191	7¼	+¼
CellTch		70	1 15/16	+1/16
Celcm s		249	4¾	+¼
CellCm		4530	30	+¾
Celrin		307	22¾	+1½
CellrInf		53	7	....
Cencor		6	1⅞	....
CntlSB	.40	52	8⅞	−⅝
Centrbk		255	7¼	....
CentxTl		1024	19½	+⅜
Centcor		633	29	−¼
CnBsh	.80	73	14	....
CtrCOp		27	4⅜	....
CFidBk	1.24	36	29¼	+¾
CtrlHld		13	2⅞	−¼
CJerBc	.90	11	18	+½
CPaFin	.40	2	13½	+¼
CRsLfe	.26	37	4⅞	−¼
CnSorn		27	23¾	+½
Centuri		20	1½	−⅛
CntGld		10	13/16	+⅛
CntyBc	.30	40	3⅜	....
Cenvst	.48	18	7⅛	....
Cerdyn		54	3¼	....
Cerbco	.06	32	3⅛	−⅛
Cerner		14	13¼	+¾
Cetus		1156	15⅛	....
Chalone		17	10¼	+⅜
ChncCp		5	1¾	....
Chanin s		10	9⅞	+⅛
ChrmSh	.12	1077	8¾	−⅛
ChrtFdl		70	2 3/16	−1/16
ChtFSB	.50	6	11¼	+¼
ChtOne	.52	134	15¾	....
Chrtwl		543	5/16	−1/32
ChkPt		597	10⅞	−¼
ChkTch		5	2¼	....
ChmDsg		263	12½	−½
Chemfx		161	4¾	....
ChmFin	1.00	2	33½	+1¼
Chmpwr		152	14¾	....
ChryCp	.12	86	7⅜	+⅛
ChesUt s	.84	21	12	+½
Cheshre	1.00	371	12	+¼
CheySft		542	3⅝	−⅛
ChDock	.27	23	18½	−¼
ChldDis		17	3½	....
ChldWld		130	11¼	−¼
ChipsTc		3603	20½	+½
Chiron		569	26¼	−¼
Chitnd	.68	13	11	−⅛
Chronr		11	1 7/16	−1/16
ChrDwt	.28	76	15⅝	−⅛
Cimflex		40	1⅝	....
CinnFn	2.44	222	76	+1⅜
CinMic		4	4½	....
Cintas	.17	66	44⅜	+1
Cipher		1415	7¼	+¼
Ciprico	.20	21	3⅜	−⅛
Circadn		3	1⅜	−¼
CirclFA		73	5⅜	−¼
CircInc	1.14	32	11⅞	+⅛
Circon		55	4⅞	+⅛
Cirrus		2026	13⅜	+⅜
Cisco		888	22½	+½
CtlMlg	.48	286	3⅛	....
CtrlRs		25	4	....
CnvSol		9	2⅜	+⅛
Cooker		73	2¾	−⅛
CooprD		3	2⅝	....
CooprL		54	7½	....
Coors B	.50	465	18⅜	−⅜
Copytle		250	12½	+½
Cordis		64	14	−¼
CoreSt	1.92	2437	38⅝	−¼
CrnrFn	1.00	21	6	....
Cornucp		73	1⅝	−⅛
CpCapit		1319	¼	−1/32
CorpDt		20	4⅛	....
CorpSft		214	10¼	−¾
CorctCp		363	14⅝	....
CosmFr		143	6¾	+⅜
Cosmo		4	11¼	+⅛
Costar		7	15	−¾
Costco		3390	30¾	−⅜
CtnSLf	.24	12	7¼	....
CtryLk		2	9¼	−⅛
CntyBk		24	2⅛	....
CourDis		1	4⅛	+⅛
CousPr	.60	28	15	....
Covngt		242	¾	−1/32
CrckBrl	.07	2203	29¼	+⅛
CrayCm		9053	4⅞	+¼
Crestar	1.32	246	28⅜	....
CrstFdl		192	6½	....
Criticre		26	2⅝	....
Cronus		57	12¼	−¼
CropG		31	6½	+⅜
CrosTr		448	6½	+⅛
CrwnAn		10	7⅜	+⅝
CwnBk		53	18½	....
CrwnRs		590	7⅜	−½
CullnFr		11	9⅝	−½
Culp	.08	4	8	−¾
CumbFd	.48	56	13¾	+¼
Cybertk		161	6⅛	+3/16
Cytogn		263	6⅛	....
Cytgn pf		115	25¼	....
—D—				
D&N Fn	.60	161	10⅝	+1⅛
DBA		35	4⅜	....
DDI		180	3¾	....
DEP		31	7⅛	....
DF Sou		13	12¾	....
DH Tch		51	12⅛	....
DNA Pl		1592	7⅛	+⅜
DS Bnc	1.60	31	17½	....
DSC		6173	12	−⅜
DST	.16	40	10½	+½
Dahlbrg		13	11¼	+½
DlyJour		4	14¼	+½
DairyB		2	7¾	....
DaisySy		335	17/32	+1/32
Daka		737	½	+1/16
DalSem		2782	7⅛	+⅛
DmnBio		290	15/16	−1/32
Dta IO	4.15	72	3⅛	−⅛
Datflx		240	9⅞	+¼
Datkey		6	8¼	+½
DtaMea		1	5⅝	....
DtSwtch		246	2⅛	−¼
Datphz		38	1⅛	....
Datscp		174	22¼	−⅛
Datron		48	10¼	....
Dauphn	1.42	29	29¾	−¼
Davox		32	4½	....
Dawson		14	4⅞	....
DebShp	.20	122	13⅜	+½
DeerfSv	.80	1	26¼	....
DefnInc		86	1½	−¼
DekibE	.20	517	31¾	+1¼
DklbGn	.45	11	40¾	+1½
DelTaco		1	3	−¼
DelaOts		10	13	....
DellCpt		37	6⅛	−⅛
Delpinl		97	6	....
DepGty	1.56	3	26¾	+½
DsgInc		241	2⅞	−¼
DetSys		24	6¼	+¼
Devon		155	12	−¼
Diagnst		1540	11⅜	+⅞
Dial Re	1.68	7	15¼	+½
Dibrell	.72	17	23	+¼
DClark		25	5⅞	....
Digi Int		252	9¼	....
DigMic		78	25¼	+½
ErieLac		2	52	−2
Erlylnd		665	8¼	+½
EsxCty	1.32	1	18¾	+¾
EvnSut		100	25	....
Evans		33	3	−⅛
Everex		3884	9¼	+¼
Exabyte		732	15⅜	....
Exar		40	6¾	−¼
ExcelBc	.68	174	8⅜	+¼
EXTON		489	2¾	−¼
Exide		67	9	....
Expln		4	26¼	....
—F—				
F&M	.44	2	18¼	+¾
FM Nat	.50	5	13¼	....
FDP		2	5⅛	....
FHP s		11290	17¼	−3¼
FMS Fn		28	8⅜	+⅛
FRP Pr		1	13¼	−¼
FSI Int		116	4¼	−½
Fabric	.16	2	13¼	....
FairCty	.40	75	6¼	+¼
FairFst		5	6	+¼
FalcOil		64	4	+⅛
FamBc	.50	29	6⅝	−⅛
FamStk		10	1 15/16	....
FamRst		449	1¾	−⅛
FaradE		74	6⅛	+½
FrmHm	.07	41	12⅝	....
FrmH pf	3.25	159	22⅝	+⅛
Farr	.30	15	11¼	+½
Fastnl s		308	17	+¼
FdScrw	.40	6	12¼	+1¼
Ferofls		42	15¾	....
Fibronc		219	5⅞	+¼
FidBnc	.60	56	17⅞	−¼
FFdVA s		3	7	−¾
FifthT s	.96	306	31⅛	+⅜
50-Off		13	3⅜	+⅛
FigieA s	.50	496	23½	+⅜
FileNet		80	12	....
FnClr		2	16½	−1½
FinNws		183	7	+¼
Fingmx		528	1¾	−⅛
Finigan		232	14¾	+½
FAlaBk	.92	323	16⅞	+⅛
FstAm	2.20	74	44½	....
FtAmB pfE	1.90	3	20⅛	+1
FtABcp		15	9/32	....
FtAFd	.80	15	11¼	....
FtATn	1.25	123	18⅝	....
FACant		5	5½	....
FBOh	1.50	196	25½	−¼
FtCapt	1.00	x1	20½	+¾
FtChat	.32	73	21	+⅛
FstCity		10	9⅜	−⅛
FColBn	.44	16	16½	....
FComB	.20	3	10⅛	+⅛
FCmBn	.64	1	19¼	−½
FComC	1.20	60	21¾	....
FtConst	.45	319	10	+⅛
FtEstn	1.12	12	28¾	....
FtEsex	.32	159	4⅛	−⅛
FtExec		15190	3⅛	+¼
FExpfE	2.18	391	7¼	+1
FExpfF	2.88	198	9⅞	+½
FExpfG	1.56	552	4	+¼
FExpfH		3138	3½	+⅜
FExwt		50	¼	+1/16
FtFaml		65	1	+⅛
FFdGa		10	5¾	....
FtFdMic	.60	16	15	....
FFdEH	.28	9	6	+¼
FFFIM	.60	7	21¾	−¾
FFdLaG	.56	5	11	....
FtFdSB		1	6⅜	−½
FtFdSC		23	5	−⅛
FFdAla	.90	48	10¾	....
FFdPry		13	7½	−1½
FFdPR	.52	12	9⅛	....
FtFncl	1.20	2	46	....
FtFnCp	.64	81	14½	+¼
FtFnHd	.48	16	10¾	+¼
FtFIBk	.96	167	25¾	+¼
FtGaHd		5	5¼	−½
FtGoldn		4	6	−¾
FtHaws		435	22½	+⅛
FHomF	.24	1	12	−⅜
FtIllCp	.44	42	8⅞	−⅛
FstIndi	.28	15	14	+½
FtIntBs	.40	7	9¼	+¼
FInsWi	.72	1	21⅝	+⅛
FtIowa	.20	75	6	+⅛
FtLbty		5	8¼	+¼
FtMich	.72	36	23	+⅛
FMidB s	.48	56	20½	−½
FtMiss		102	12¼	....
FMWA	.20	1	9½	+¼
FNlGa	.64	28	22¼	+½
Glamis		96	2 9/16	+1/16
Glenex		45	1⅞	....
GoalSy		678	13¾	−⅜
GoldEn	.36	36	8⅝	+½
GldPou s	.04	35	8¾	−¼
GoodGy		124	13¾	−¼
Goodmk		11	12¼	+¼
Goody	.05	287	11	+⅛
GouldP	.76	730	16⅞	−¼
Gradco		620	9¼	−⅛
GranCo		1	4	....
GrantSt	.36	40	4¾	....
Grphln	.07	55	7¼	+¼
GrphSc		453	10⅛	....
GACm	.02	493	7½	−¼
GtARc s		5	5	−1/16
GrtBay	.60	4	9⅝	....
GtFalls	.50	1	10	+¼
GtLkBc	.80	11	16½	−¼
GtSoBc		43	7⅝	....
GtNYSv	.48	637	6⅜	+¼
Green	.60	35	30½	+⅝
GrnRhb		487	10⅝	+⅜
GrnwFn	.28	21	7½	+¼
GrnwPh		832	4	−⅛
GrndSu	.60	3	11	−¾
GreyAd	2.80	5	150	−5
GrifTch		52	6⅞	−⅛
Grist		174	8¼	−⅛
Grosmn		1975	4⅛	+⅛
GroveB	.36	20	8	+¾
Grdwtr		54	18¼	+¼
GrubER	.72	62	7⅛	....
GuestS		238	6⅛	....
—H—				
HHOilT		115	7¼	+⅛
HBO	.30	1662	11¾	....
HDR		5	2⅜	+⅛
HEIMn		68	1½	....
HMO		1773	6⅜	−⅞
HPSC		33	6½	....
HadEn		305	12¼	−⅛
HallFn		2	13/32	....
HalwdE		50	7/32	−1/32
HamOil	.10	220	31¼	....
Hamnd	.10	12	4½	+¼
HanaBi		15	1¾	+⅛
Handex		35	16¼	−¼
Hanvln	.44	331	29½	−½
HrdgA s		478	17	+½
Harleys	.60	87	25½	....
Harmon	.12	25	5⅞	+⅛
HarmBc	.07	240	8	+⅛
Harold		19	3½	+⅛
HarpGp	.10	11	17½	−½
HarisHa	.04	145	2⅛	....
HrtfdSt	1.60	249	52¾	+¾
Hathw s		3	1⅞	−⅛
Havrfld	.32	30	14¾	....
Havrty	.36	12	11½	+¼
HawkB		26	8	....
HawkC s		3	5	+½
HlthCo		198	13	....
HlthCS	.05	653	17¼	−¼
HlthImg	.02	52	8⅝	....
Hlthco		185	13¾	+¼
Hlthdyn		426	9⅜	+¼
Hltsrc		697	9⅞	−1⅛
Hlthwcs		17	5⅝	....
HeartFd	.40	33	14	+¼
Hrtlnd		5	15	....
HchgA	.16	185	12	−⅛
HchgB	.06	16	12	+½
Heekin		7	35¾	....
HeistC		5	12½	....
HelenT		581	13½	−⅛
Helian		5	5¾	+½
Hemody		39	1¼	....
HnlyGp		280	38½	+½
Hnlyln		184	8¼	+¼
HnlyPr		493	7⅜	+⅜
HrtBkcp	.52	54	8¾	+¾
HrtgBc		262	3⅜	−⅛
HrtFS s	.50	3	19½	....
HiberSv	.36	32	8½	+½
Hickam		10	12	+⅜
HighlSu		599	3¼	+¼
Highwdg		4	¾	−1/16
HilbRgs	.28	522	15¼	−⅛
Hitox		55	7¼	−¼
Hogan		25	3⅞	−⅛
HldyRV		57	2¾	....
HlwdPk		538	26	−¼
HmCty	.96	18	21½	+½
HmBen	1.20	1	35	....
HmFChr		3	9¼	....
HFdlnd	.30	93	13½	+¼
HFMds	.28	5	9½	−¼
HmFncl	.40	35	17¾	+⅜
Hmeint		859	1⅜	+1/16
Intelcal		407	12¾	....
IntelEl		1220	26	−¾
Intera		2390	11⅞	+¼
Intcarg		102	9½	....
Intrfcln	.24	879	17⅝	+⅜
Interfc		3	4⅜	−⅛
Intgph		3877	19⅜	+⅜
IntrmSy		143	1 13/16	+1/16
Intrleaf		1138	5⅝	+⅛
Intrmgn		720	4⅞	−⅛
Intmec		2762	19½	−¾
IntmetC	.20	25	7⅜	−⅛
IntAm		103	7/16	−1/16
InBcst		24	10⅛	....
IntCnt		35	3	−¼
InDairA		159	50¾	+1½
InDairB		4	50	....
IGame		230	26¾	−1½
IntLse	.10	856	23	+⅛
IntLs wt		2	5⅜	−⅜
IMP		703	1 9/16	+⅛
InMobil		2271	5	+⅜
InMbl pf	2.50	25	13	+⅜
IntRsh s	.20	29	9¼	+½
IRIS		31	7/32	....
IntShip	.20	19	20½	....
IntTotlz		262	4 9/16	−⅛
Intphse		15	6¾	+¼
Intpnt		20	6¼	....
Intspec		134	2⅜	+⅛
Intrtrn	.20	97	14¾	+¼
Intvce		423	23	−¾
Intrex		197	2¼	−½
Invcr		2	10	+½
InvstFn		132	3⅞	+¼
InvSav		4	5¼	+½
InvTitl	.04	17	5½	−¼
Invtrn		60	4	....
Iomega		4626	4	+⅜
IowaN s	1.28	8	42½	−1½
IowaSo	2.28	6	33¼	....
Isco	.20	1	11	....
Isomdx		82	12	−¼
ItoYokd	.51	10	102¼	+5¼
—J-K—				
JJ Sns		189	8⅛	−⅛
JBRst		559	6¼	−⅛
JG Ind		4	1⅜	....
JLG	.20	25	16⅜	−⅛
Jacbsn	.50	84	21¼	−½
Jacor		71	5⅞	+¼
Jaguar	.19	71	14	....
Jason		351	13¾	....
JayJacb		72	6⅛	+¼
JeffrGp	.20	3	12	+½
JefBsh	1.00	138	21¾	−1
JeffNl	.36	14	7	....
Jetbrne		90	13/16	−⅛
JfyLub		135	2⅜	....
JHansn		31	2¾	....
JWA		17	21¾	−½
JohnsSv		45	6½	−½
Jonlcbl	1.40	321	11¼	+⅜
Jonel A	1.40	551	10¾	....
JneMed	.08	17	10⅜	−⅛
JoneSpc		1	1½	+1/16
Joslyn	1.60	49	28½	+¼
Juno	.20	26	19¼	−⅛
Justin s	.40	194	16⅜	−⅛
KLA		756	7	−⅛
KMS	.12	14	4⅛	....
KTron		18	7¼	....
Kahler		15	14¾	....
Kaman	.44	378	7⅞	+⅛
Kamnst		1	4¾	....
Karchr s	.08	142	10	−¼
Kasler	.10	14	9⅛	+⅛
Kaydon	.40	33	29½	....
Keegan		223	8¾	−¼
KlySA s	.66	261	35	+¼
KyCnLf	.40	52	14½	+⅛
KyMed s		15	23½	+1¼
Keptel		2	6¼	+½
Kevlin		135	1½	−⅛
KeyCen	.60	71	13½	+¼
KeyPrd	.25	47	3⅜	....
KeyTrn		584	4⅞	+⅛
KeyFnc	1.08	15	22½	+½
Kimbal	.60	23	20¾	....
KimEns		605	5⅜	....
KndrLr		745	3⅛	−¼
Kinetic	.03	56	5⅞	....
Kirschn		97	12¼	....
KnapeV	.56	21	14¾	−¼
KnwlW		210	20¼	−¼
Komag		86	10	+⅛
Koss		164	4 3/16	+1/16
Krug	.03	11	4⅛	+⅜
Kulcke		149	6⅞	+⅛
Makita	.65	1	94½	+6½
Mallard		110	4	−½
Mallon		122	7½	+⅛
Mantrn		16	1½	....
Manitw	1.00	81	19¼	+⅜
MfrsNt	2.16	1621	50	+¼
MarbFn		143	5¾	....
Marcor s		211	7⅝	−⅛
Marcus	.28	125	15¼	....
Mariet		408	23½	+¼
MarnDr		1525	8¼	−⅜
MarkCtl		25	5½	....
Markels		21	21¾	−¼
Marqst		53	7⅛	+⅛
Marsms		14	16¼	....
MrshSu	.36	11	18½	+½
Marshl	1.08	148	33½	+¼
MartnL		354	6½	−⅛
MdFdBc		55	11	+⅛
Mascol		178	6⅛	+⅛
Massbk	.44	368	17⅛	....
Masstor		551	1⅝	+3/16
MaxEr		32	7¼	....
Maxim		847	9⅜	+¼
Maxtor		1127	10⅜	−¼
Maxwel	.40	33	13¼	−¼
MayflF		10	12¾	−¾
MaynOl		10	6¾	+⅜
McCaw		7697	30⅛	+1
McCor s	.44	874	21¾	....
McFarl		10	10½	−½
McGrth		365	18	−¼
MechTc		6	4	....
Medar		3	1⅞	....
MedcC s	.04	3587	18	+¼
Medex	.09	75	8⅞	+⅛
Medgn		83	5¼	+½
MedAct		61	1 7/16	−3/16
MedCre		640	23⅛	+⅞
MedDv		20	2 9/16	−3/16
MedImg		327	10¼	....
MedSh s		568	20	+¼
Medstat		7	11½	−¼
Medstn		1172	5	−¾
Melaml	.24	17	11¼	+¼
MellonP	.72	24	5¼	....
Mentor	.16	342	12⅛	+¼
MentG s	.20	1515	17	....
MercBc	1.40	252	24¼	−½
MrcBk s	.80	308	23¾	....
MerCaA		10	⅛	....
MrchNt	1.20	75	25⅜	+⅛
MercGn	.60	12	14⅜	+⅜
MrdnBc	1.20	529	18	+⅛
MrdDia		8	4¼	....
MerdIns		12	4¼	+⅜
Meritr		381	2½	....
MeritCp		8	7	+¼
Mermck		198	1¼	+¼
MeryG s		861	20⅝	−¼
MeryLd	.40	166	5	....
MesaAr		10	7¼	−¼
MetCoil	.12	10	4¼	−½
Metcalf		1	25¼	−½
MethdA	.07	108	5¼	+⅛
MetAirl		706	4⅞	−½
MetrBc	.40	40	7⅞	−⅜
MetbkF	.40	25	2¾	....
MetrFd		205	7¾	....
MetFSe		10	7½	+¼
MeyerF		80	16¼	+¼
MichAnt		34	4	+¼
MichlF	.20	1059	15½	+½
MichNt	2.00	1019	44	−⅜
Micrage		22	9½	....
Micram		532	5⅛	....
Micrdy		9	3¾	....
MicrTc		7637	12½	−½
Microp		1281	5⅜	−¼
Micros		65	4⅜	+3/16
MicSem		146	1⅞	....
Micrcs		88	16½	....
Microlg		17	9½	+½
Micsft		4307	98	−1¼
MicrLb		52	9/16	+1/16
MidABc	.60	1	17	+½
MidAm s	1.04	11	20	−½
MdConn	.72	1	9¼	−½
MdMaine	.40	400	7½	−¼
MidSou	.24	378	8¾	−⅛
MdsxW	1.84	3	24¼	−¼
MidlCp	1.88	3120	20½	+¼
MdwCm		203	3¾	....
MidSth		63	13¼	....
MdwGr	.70	49	18	−¼
MilrBld	.04	25	4½	....
MillrHr	.52	280	19⅛	....
Millcm s		367	15⅞	+⅛
Milwins		345	9½	−1
Mindscp		117	8⅛	....
NHmB		107	1⅛	....
NwImag		351	13	+¾
NJ Stl	.60	13	13	−½
NewLdn		65	3⅛	−¼
NY Bcp		438	11½	+½
NwbNwk		7643	9⅜	−1⅛
NMilBc	.60	215	7⅛	+⅜
NwldBk	.50	182	7	....
Newpt	.16	88	9⅛	....
NwprtN		1	4¾	−½
NwpPh		734	3	+⅛
NiagEx	.32	1	6	+½
NichRs		24	9	−½
Nike B	.80	1971	54¾	+1
NbleDr		451	8¼	−¼
Nordsn	.72	12	47¼	−1¼
Nordst	.30	x7246	28	−1¼
NormOG		17	2¾	+¼
NwNG	1.64	197	25	....
NTelpd	.36	1	8¼	....
NWPS	1.46	65	19½	−½
NorwFn	.60	25	6½	+½
NovaPh		226	4¾	+⅛
NvP wt93		6	1⅝	....
NvP wt98		8	1⅞	....
NovaCr		525	15⅛	−¾
Novmtx		387	3 13/16	+1/16
Novar	.01	7	9¼	....
Novell		3860	35⅞	+¾
Novelus		1602	13⅞	+¾
NuWst		450	2⅞	+⅛
NuWt pf		2	27	−3
NucMet	.10	7	7¾	−¼
NuclSpt	.05	144	8	−¼
Nucrpl		103	6¾	+⅛
Numrc		48	2	+¼
Nutmeg		467	5	−¼
NuMed		205	4⅜	−¼
NuVisn		25	4⅝	....
NYCOR	.08	97	2¾	+3/16
NYCR pf	1.70	76	16	....
—O-P—				
OakHill		4	4⅞	....
OcuUr s		142	15¾	+¼
Oceaner		1663	11⅛	+⅛
Octel		7808	22⅜	−½
OfcClub		78	12⅞	+⅜
OfcDpt s		1079	13⅜	−⅛
OffsLog		1582	10½	+⅛
OhioBc s	1.28	12	24	....
OhioCa	2.32	548	43¼	+½
OldKnt	1.06	1293	27⅜	+⅜
OldNB	.84	49	26¼	+¼
OldRep	.74	119	24⅜	+¼
OldStn	1.56	335	11⅜	+⅜
OldS pfB	2.40	53	16½	....
Olympus		5	6¼	....
OmniC s	.24	256	13¾	+¾
Omnicm	.98	1693	23⅛	....
Onbcp	.12	10	9⅝	+¼
Oncogn		37	2	+⅛
OneBc		141	⅞	....
OnePrc		4	8	−¼
Optek		67	3 9/16	+3/16
Opto		4	3⅞	....
OpticC		87	6¼	−⅛
OpticR		299	24	−¾
Optrtc		305	8⅝	+⅛
Oracle s		6785	22½	+½
Orbit		10	3½	+⅛
OregMt	1.95	110	17½	−½
OrfaCp		649	9/32	+1/32
OrntFd		14	8½	−⅜
Orthmt		204	8½	+¾
Osborn		51	9¼	....
OshBA	.41	1608	33¼	−1¼
OshkT B	.50	205	9½	+¼
Osmnc		62	15¾	+½
OttrTP	1.56	38	24	−¼
Outlet		30	18½	+¼
PF		6	2 11/16	....
PHP		10	7¾	+½
PAM		29	1	−1/16
PCA Int		74	5⅞	+⅛
PCS		32	15¼	....
PDA		187	5	....
Pacar	1.00	812	41⅛	+1
PacAgr		90	2⅝	−1/16
PacBnk		14	28	....
PacDunl	.52	15	15¼	+¼
PacIntl		128	9/16	−1/16
PacNuc		14	6⅜	+⅛
PTelcm	1.04	293	25	−¼
PacifC s		6372	19¾	−3
Palfed	.05	3	12¼	....
Pantch		220	1⅞	....
PancMx	.15	111	6	+¼
ParmTc		707	22¾	+¼
ParisBu	.18	66	8	−⅛


57.46 £ 58.33
7.48 £ 7.63
17.58 £ 17.97
66.40 £ 66.87
66.34 £ 68.14
63.34 £ 64.42
34.70 £ 34.84
0.86 £ 0.86
40.98 £ 41.76
15.01 £ 15.03
78.49 £ 78.49
91.80 £ 93.27
31.99 £ 32.24
74.34 £ 75.09
20.57 £ 21.03
-0.91%
1.49%
2.21%
-2.19%
0.48%
-1.60%
-0.82%
-0.12%
0.28%
-5.47%
-0.81%
0.79%
-0.51%
0.48%
0.48%
£ 7.52
£ 17.58
£ 68.37
£ 67.82
£ 65.47
£ 35.13
£ 0.87
£ 41.65
£ 15.90
79.13
£ 74.
£ 20.92
£ 104.2

28 day summary with change over previous period

Tweets	Tweet impressions	Profile visits	Mentions	Followers
66 ↓21.4%	1.4M ↑5.1%	21.9K ↓9.1%	447 ↓9.3%	56.8K ↑1,143

October 2015 • 3 days so far...

glucose 6.6

glucose 6.6

glucose 6.6

glucose 6.6


glucose 6.6


glucose 6.6

glucose 6.6

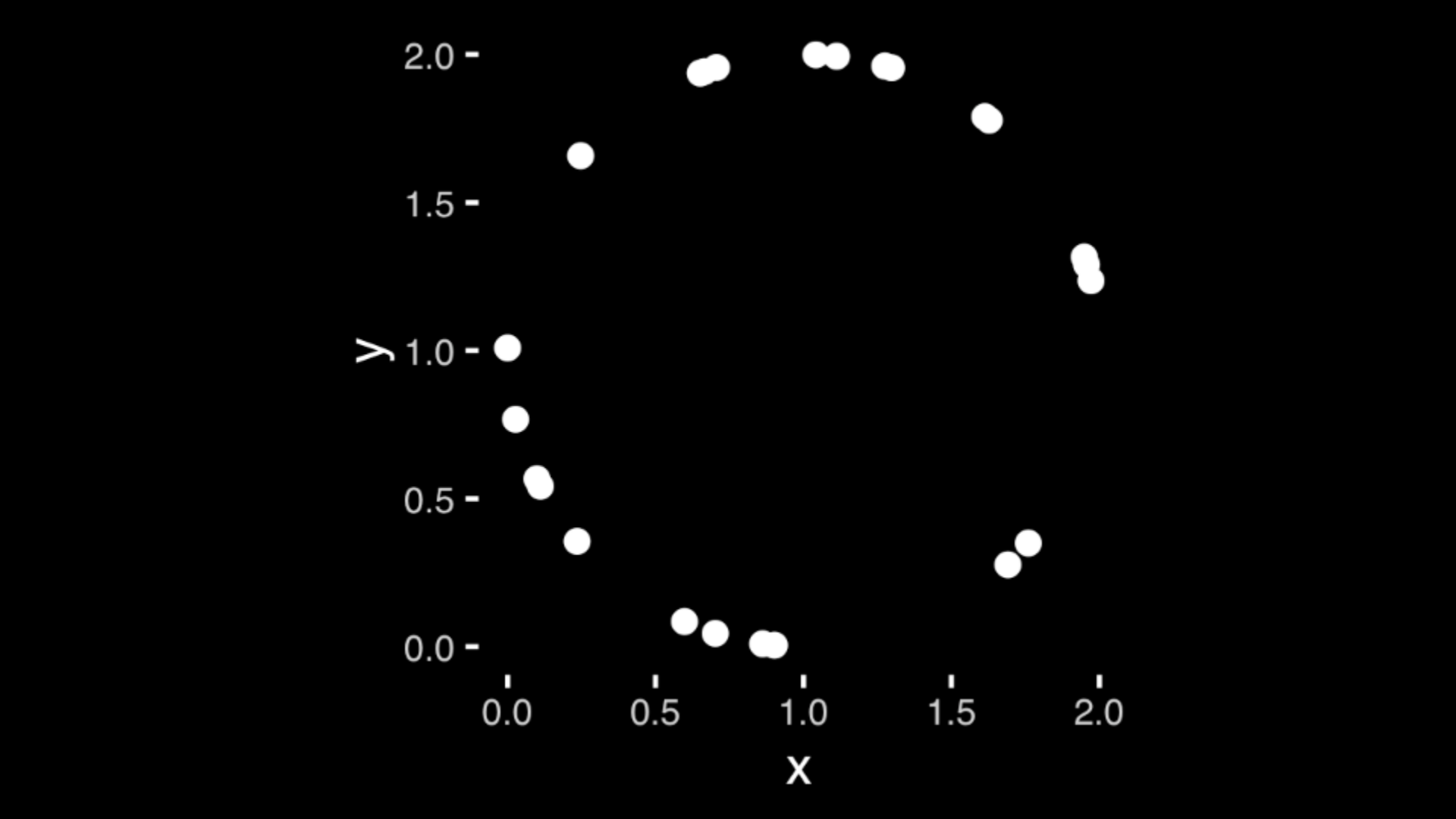

glucose 6.6


glucose 6.6

glucose 
6.6

x	y
1.972	1.236
1.112	1.994
0.000	1.009
0.665	1.942
0.235	0.356
0.247	1.658
1.275	1.961
0.702	0.045
1.760	0.350
1.691	0.277
1.628	1.778
1.957	1.290

x	y
0.111	0.542
0.902	0.005
0.598	0.085
1.613	1.790
1.298	1.955
0.651	1.937
1.949	1.316
0.099	0.567
0.862	0.010
0.027	0.768
0.706	1.956
1.042	1.999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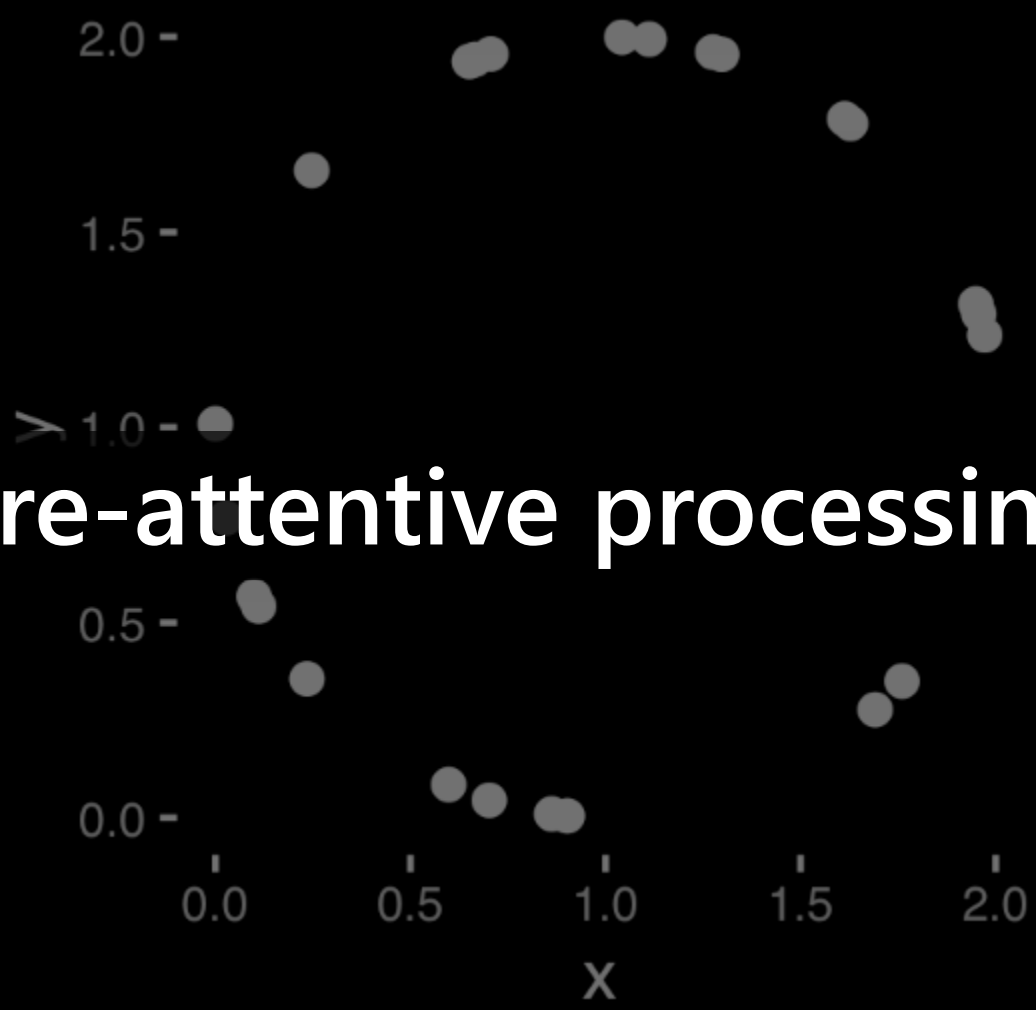
0.0
y
0.0
0.5
1.0
1.5
2.0
x



pre-attentive processing

14169265328979323846264338327930288419716939937510482097494479230781640628620899862805348234211706798214808651328230664 7

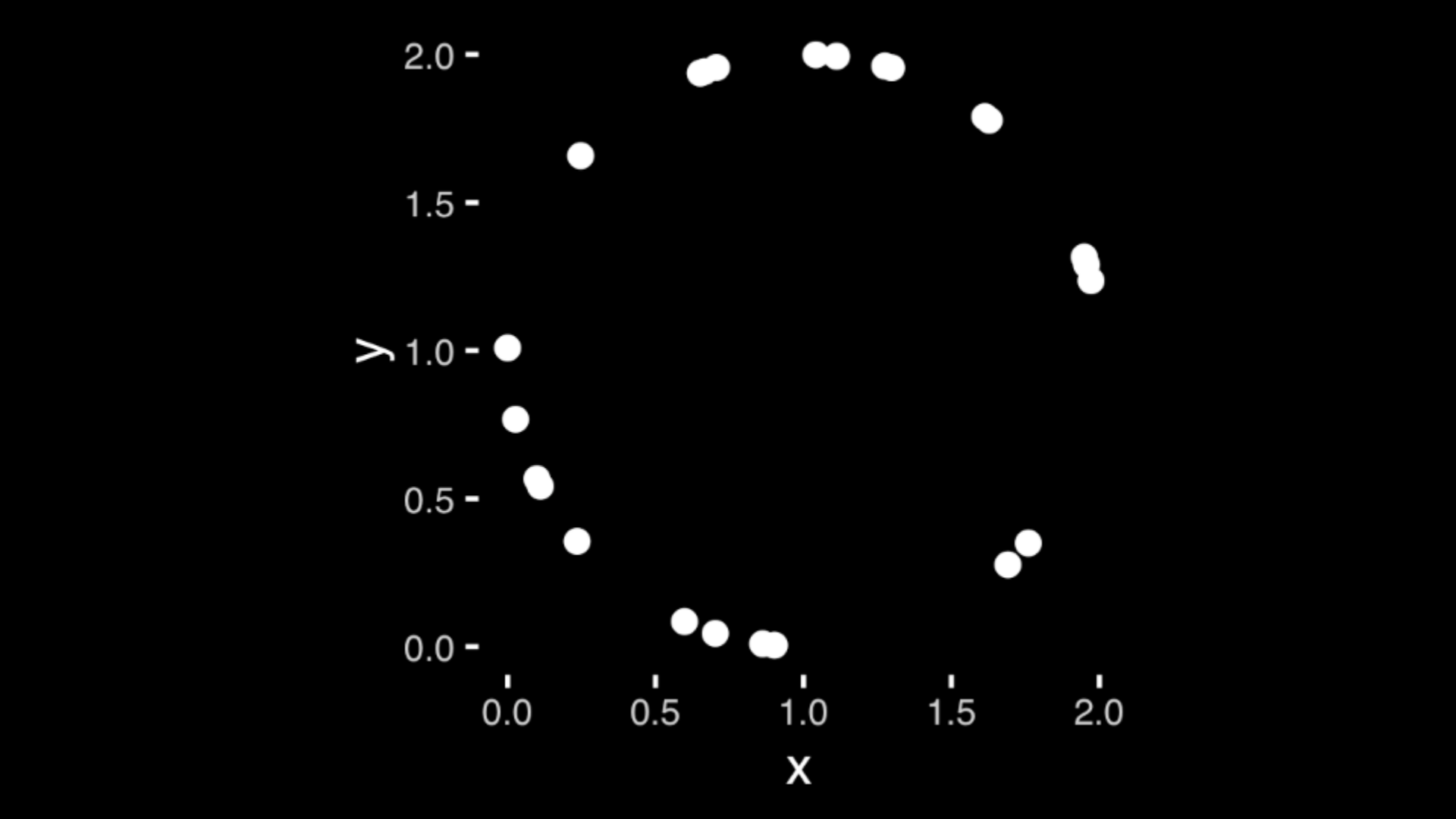
14169 26532 89793 23846 26433 83279
30288 41971 69399 37510 48209 74944
79230 78164 06286 20899 86280 53482
34211 70679 82148 08651 32823 06647

14169265328979323846264338327930288419716939937510482097494479230781640628620899862805348234211706798214808651328230664

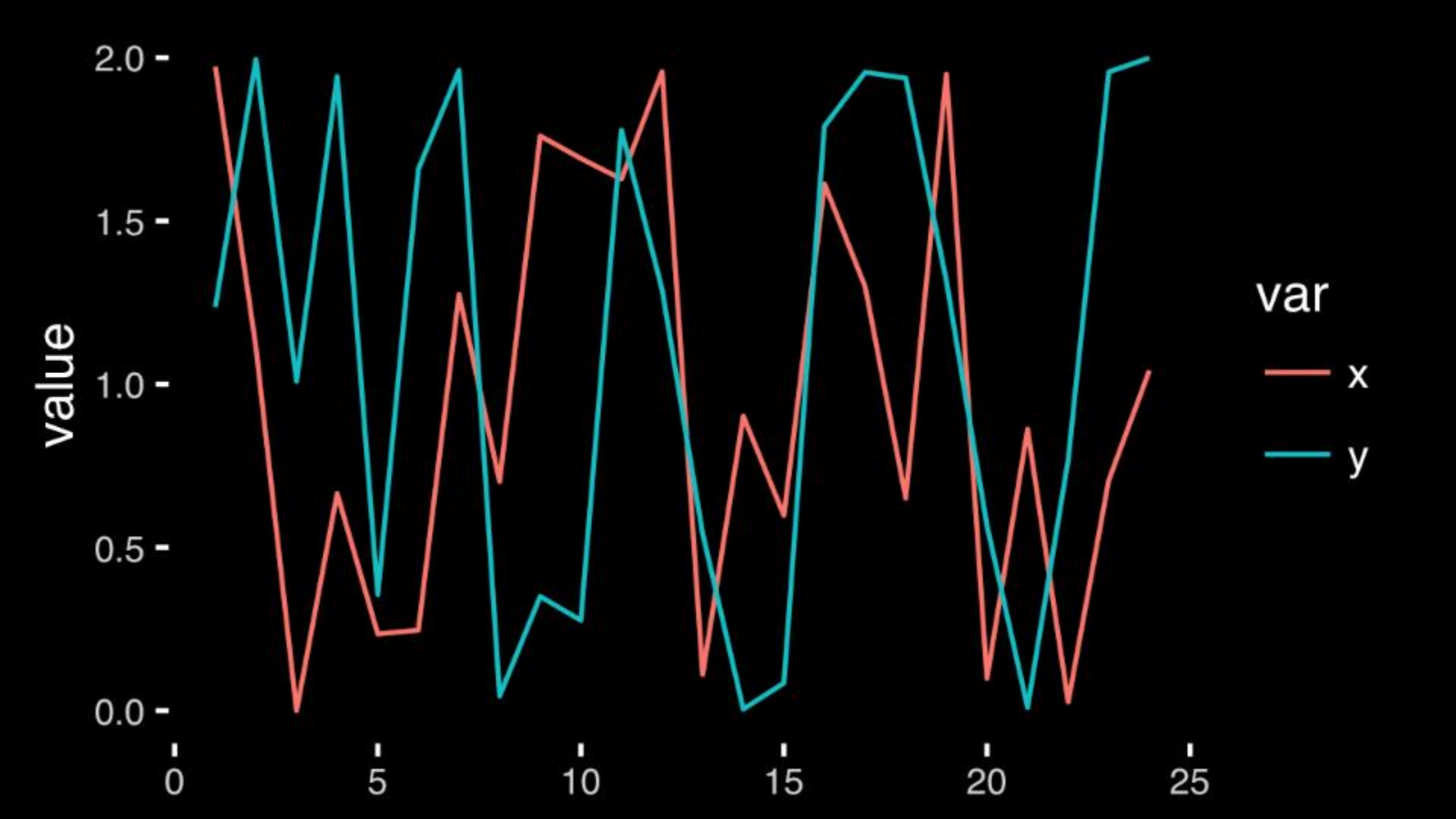
A graph is an encoding
of the data

x	y
1.972	1.236
1.112	1.994
0.000	1.009
0.665	1.942
0.235	0.356
0.247	1.658
1.275	1.961
0.702	0.045
1.760	0.350
1.691	0.277
1.628	1.778
1.957	1.290

x	y
0.111	0.542
0.902	0.005
0.598	0.085
1.613	1.790
1.298	1.955
0.651	1.937
1.949	1.316
0.099	0.567
0.862	0.010
0.027	0.768
0.706	1.956
1.042	1.999


2.0
1.5
1.0
0.5
0.0
y
0.0
0.5
1.0
1.5
2.0
x

n	x	y	n	x	y
1	1.972	1.236	13	0.111	0.542
2	1.112	1.994	14	0.902	0.005
3	0.000	1.009	15	0.598	0.085
4	0.665	1.942	16	1.613	1.790
5	0.235	0.356	17	1.298	1.955
6	0.247	1.658	18	0.651	1.937
7	1.275	1.961	19	1.949	1.316
8	0.702	0.045	20	0.099	0.567
9	1.760	0.350	21	0.862	0.010
10	1.691	0.277	22	0.027	0.768
11	1.628	1.778	23	0.706	1.956
12	1.957	1.290	24	1.042	1.999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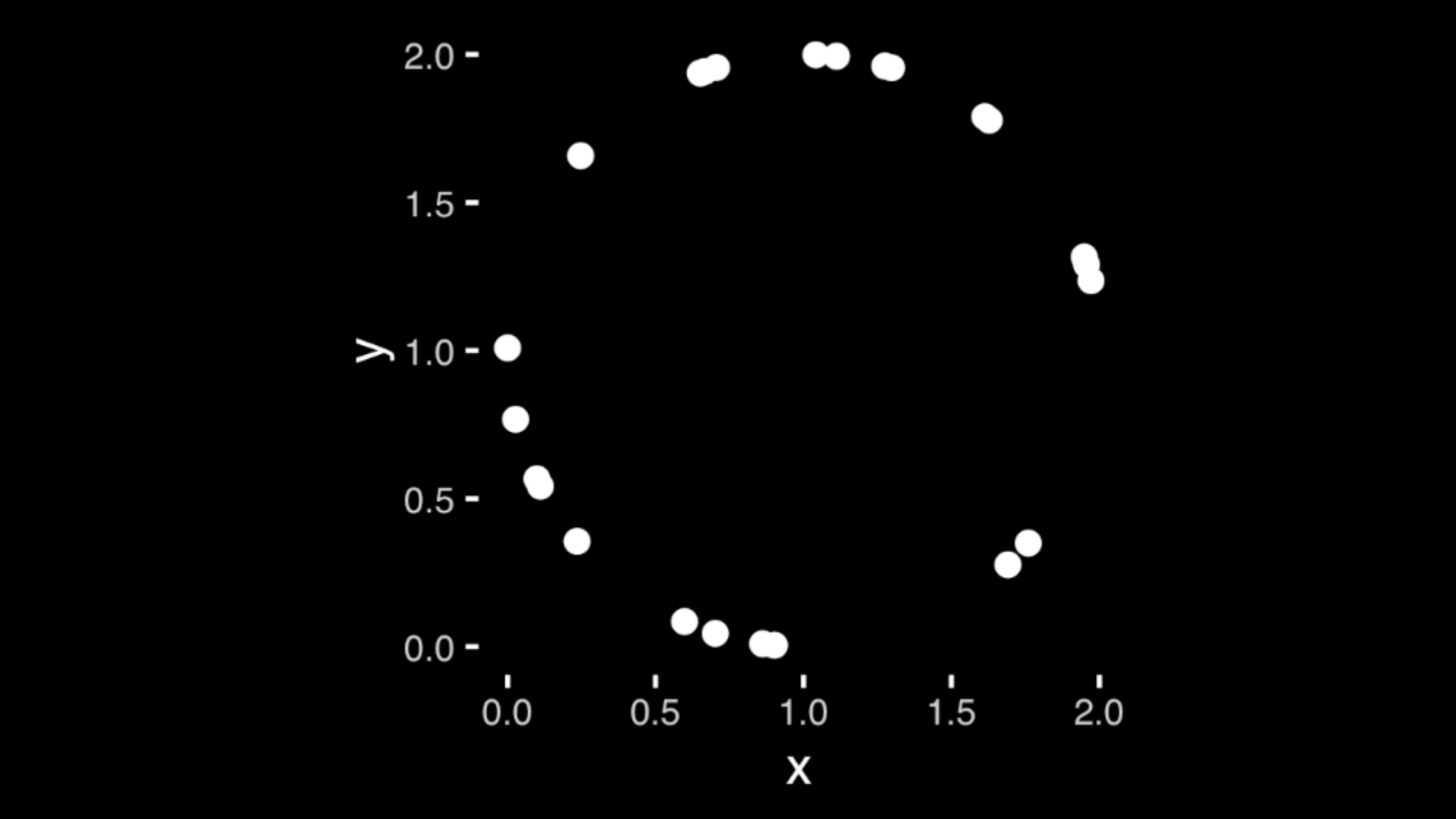
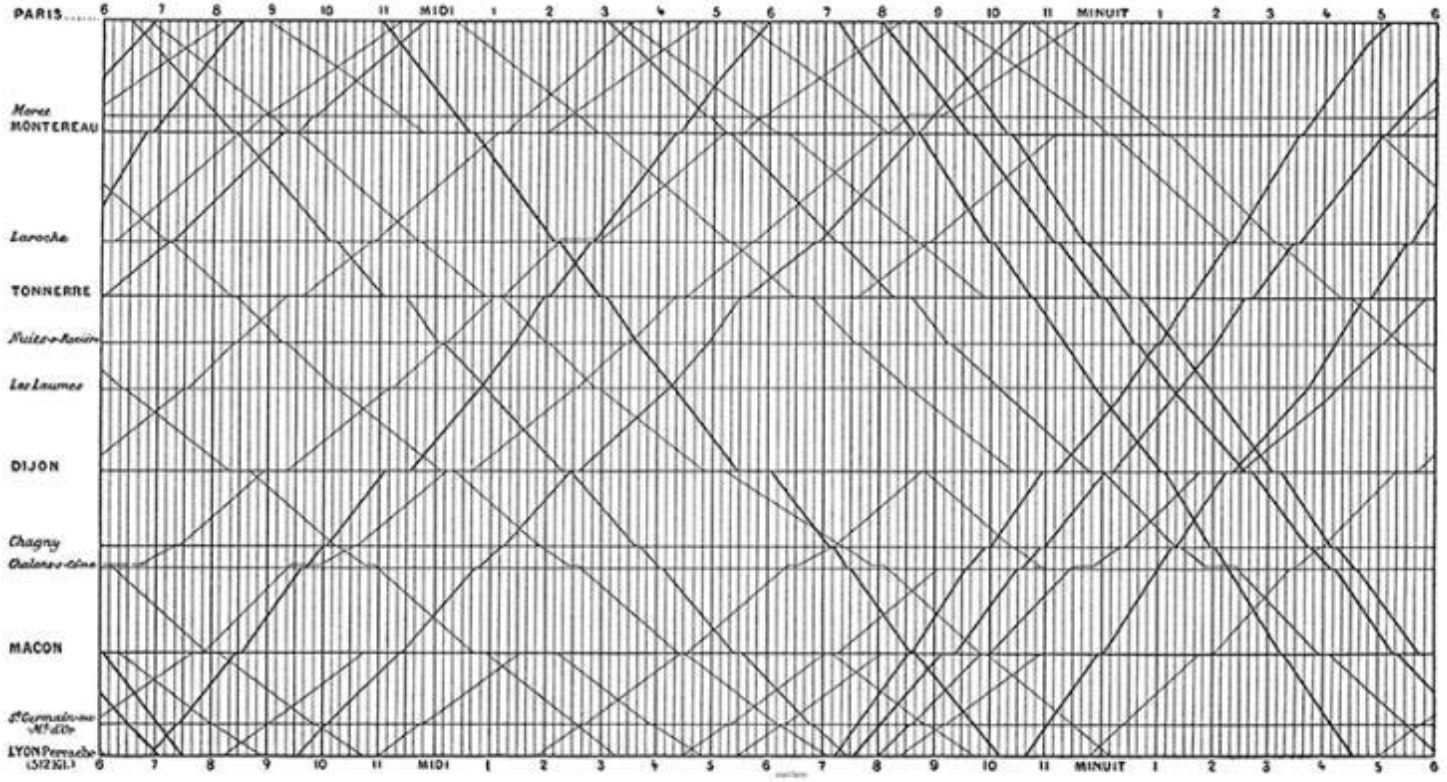
1.0
0.5
0.0
value
0
5
10
15
20
25
var
x
y


2.0
1.5
1.0
0.5
0.0
y
0.0
0.5
1.0
1.5
2.0
x

Good visualizations optimize for the human visual system



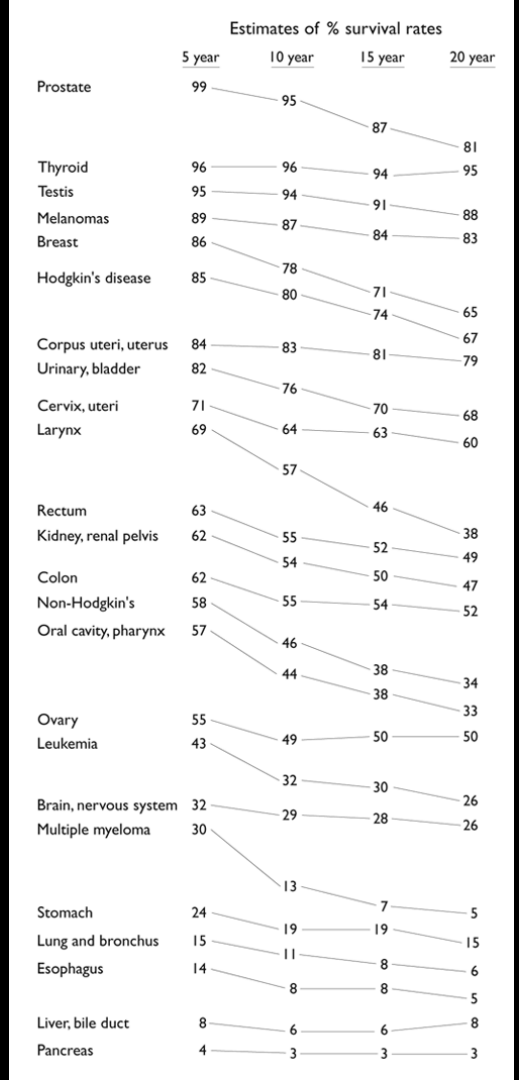
E. J. Marey, *La méthode graphique* (Paris, 1885), 20. The method is attributed to the French engineer, Ibry.

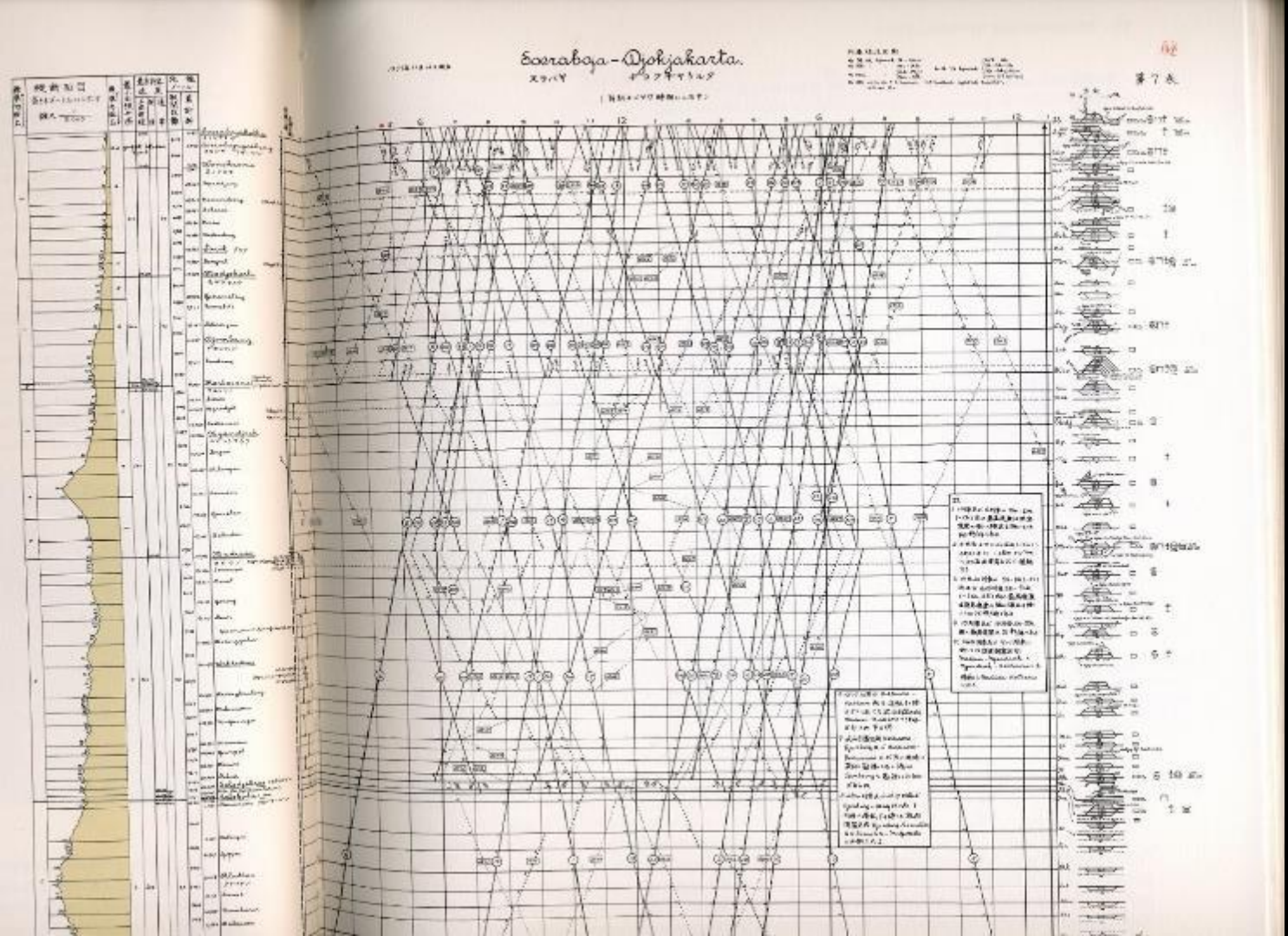
Estimates of relative survival rates, by cancer site

	% survival rates and their standard errors							
	5 year		10 year		15 year		20 year	
Prostate	98.8	0.4	95.2	0.9	87.1	1.7	81.1	3.0
Thyroid	96.0	0.8	95.8	1.2	94.0	1.6	95.4	2.1
Testis	94.7	1.1	94.0	1.3	91.1	1.8	88.2	2.3
Melanomas	89.0	0.8	86.7	1.1	83.5	1.5	82.8	1.9
Breast	86.4	0.4	78.3	0.6	71.3	0.7	65.0	1.0
Hodgkin's disease	85.1	1.7	79.8	2.0	73.8	2.4	67.1	2.8
Corpus uteri, uterus	84.3	1.0	83.2	1.3	80.8	1.7	79.2	2.0
Urinary, bladder	82.1	1.0	76.2	1.4	70.3	1.9	67.9	2.4
Cervix, uteri	70.5	1.6	64.1	1.8	62.8	2.1	60.0	2.4
Larynx	68.8	2.1	56.7	2.5	45.8	2.8	37.8	3.1
Rectum	62.6	1.2	55.2	1.4	51.8	1.8	49.2	2.3
Kidney, renal pelvis	61.8	1.3	54.4	1.6	49.8	2.0	47.3	2.6
Colon	61.7	0.8	55.4	1.0	53.9	1.2	52.3	1.6
Non-Hodgkin's	57.8	1.0	46.3	1.2	38.3	1.4	34.3	1.7
Oral cavity, pharynx	56.7	1.3	44.2	1.4	37.5	1.6	33.0	1.8
Ovary	55.0	1.3	49.3	1.6	49.9	1.9	49.6	2.4
Leukemia	42.5	1.2	32.4	1.3	29.7	1.5	26.2	1.7
Brain, nervous system	32.0	1.4	29.2	1.5	27.6	1.6	26.1	1.9
Multiple myeloma	29.5	1.6	12.7	1.5	7.0	1.3	4.8	1.5
Stomach	23.8	1.3	19.4	1.4	19.0	1.7	14.9	1.9
Lung and bronchus	15.0	0.4	10.6	0.4	8.1	0.4	6.5	0.4
Esophagus	14.2	1.4	7.9	1.3	7.7	1.6	5.4	2.0
Liver, bile duct	7.5	1.1	5.8	1.2	6.3	1.5	7.6	2.0
Pancreas	4.0	0.5	3.0	1.5	2.7	0.6	2.7	0.8

Estimates of relative survival rates, by cancer site

	% survival rates and their standard errors							
	5 year		10 year		15 year		20 year	
Prostate	98.8	0.4	95.2	0.9	87.1	1.7	81.1	3.0
Thyroid	96.0	0.8	95.8	1.2	94.0	1.6	95.4	2.1
Testis	94.7	1.1	94.0	1.3	91.1	1.8	88.2	2.3
Melanomas	89.0	0.8	86.7	1.1	83.5	1.5	82.8	1.9
Breast	86.4	0.4	78.3	0.6	71.3	0.7	65.0	1.0
Hodgkin's disease	85.1	1.7	79.8	2.0	73.8	2.4	67.1	2.8
Corpus uteri, uterus	84.3	1.0	83.2	1.3	80.8	1.7	79.2	2.0
Urinary, bladder	82.1	1.0	76.2	1.4	70.3	1.9	67.9	2.4
Cervix, uteri	70.5	1.6	64.1	1.8	62.8	2.1	60.0	2.4
Larynx	68.8	2.1	56.7	2.5	45.8	2.8	37.8	3.1
Rectum	62.6	1.2	55.2	1.4	51.8	1.8	49.2	2.3
Kidney, renal pelvis	61.8	1.3	54.4	1.6	49.8	2.0	47.3	2.6
Colon	61.7	0.8	55.4	1.0	53.9	1.2	52.3	1.6
Non-Hodgkin's	57.8	1.0	46.3	1.2	38.3	1.4	34.3	1.7
Oral cavity, pharynx	56.7	1.3	44.2	1.4	37.5	1.6	33.0	1.8
Ovary	55.0	1.3	49.3	1.6	49.9	1.9	49.6	2.4
Leukemia	42.5	1.2	32.4	1.3	29.7	1.5	26.2	1.7
Brain, nervous system	32.0	1.4	29.2	1.5	27.6	1.6	26.1	1.9
Multiple myeloma	29.5	1.6	12.7	1.5	7.0	1.3	4.8	1.5
Stomach	23.8	1.3	19.4	1.4	19.0	1.7	14.9	1.9
Lung and bronchus	15.0	0.4	10.6	0.4	8.1	0.4	6.5	0.4
Esophagus	14.2	1.4	7.9	1.3	7.7	1.6	5.4	2.0
Liver, bile duct	7.5	1.1	5.8	1.2	6.3	1.5	7.6	2.0
Pancreas	4.0	0.5	3.0	1.5	2.7	0.6	2.7	0.8





Timetable for Java Railroad line, 1937. In Tufte 1990

standard slope ‰

cross section
height in meters
1/3000

standard slope ‰

minimum radius

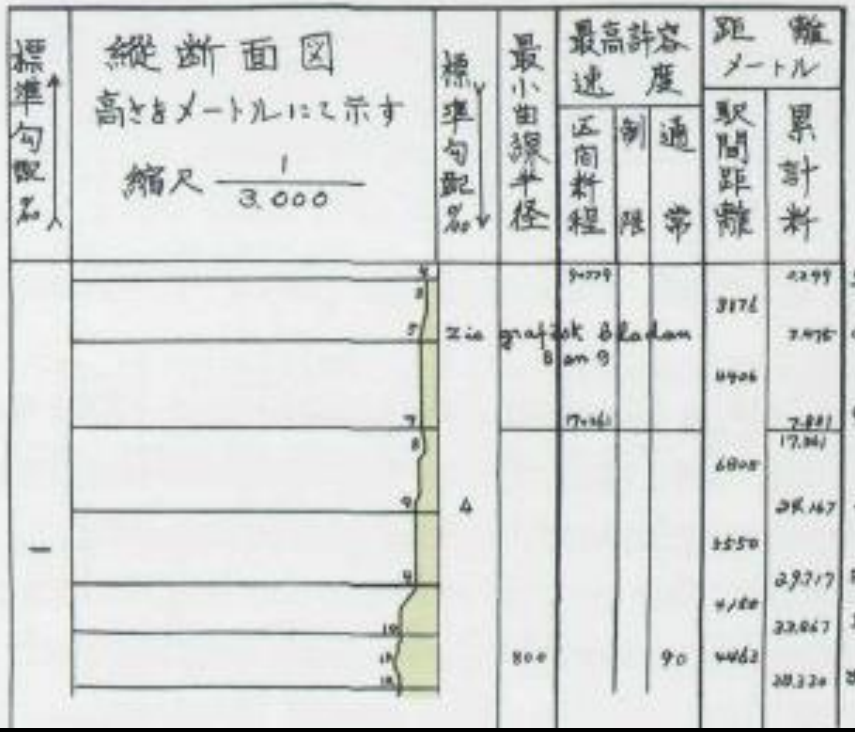
distance

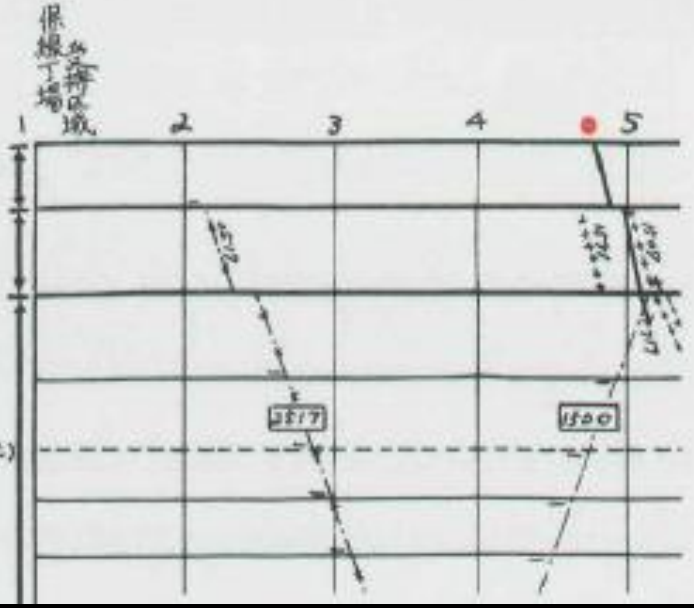
maximum speed

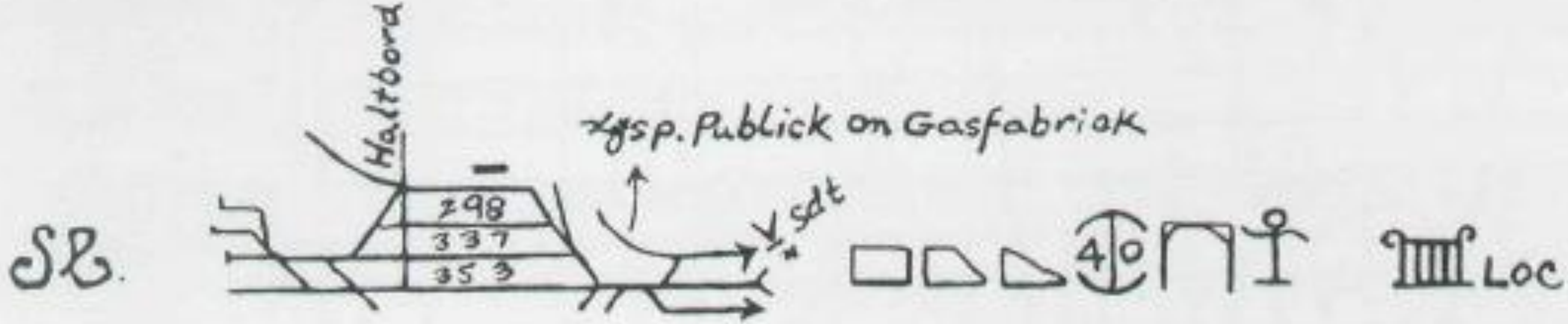
normal speed

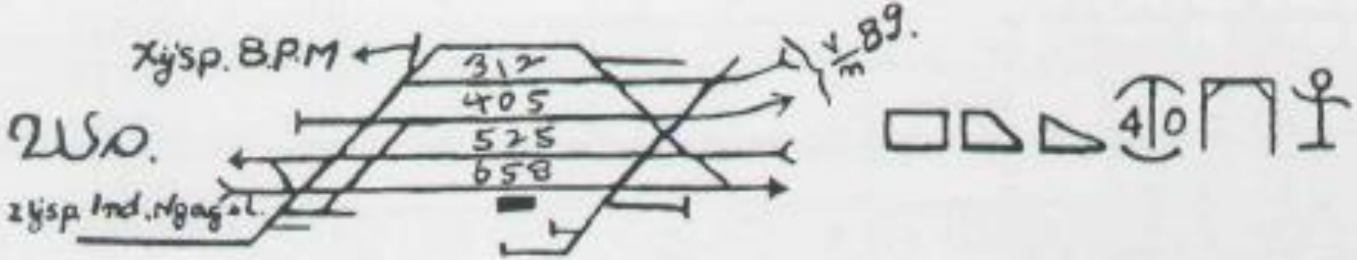
distances between
stations and
cumulative distance

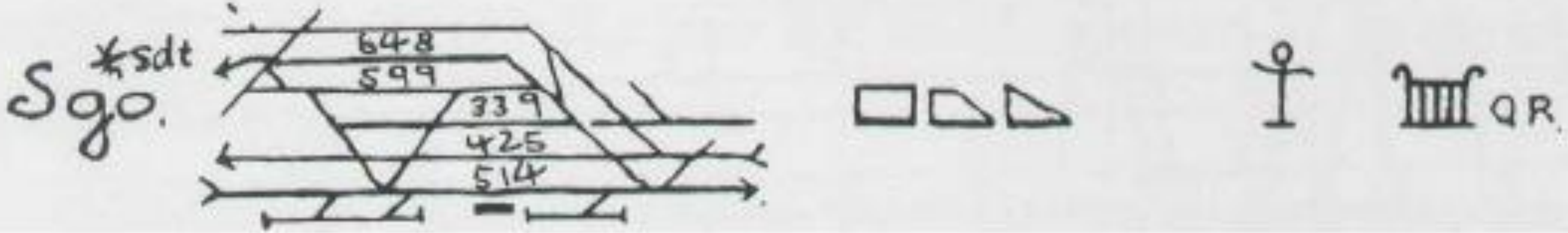
town names
major stops
underlined

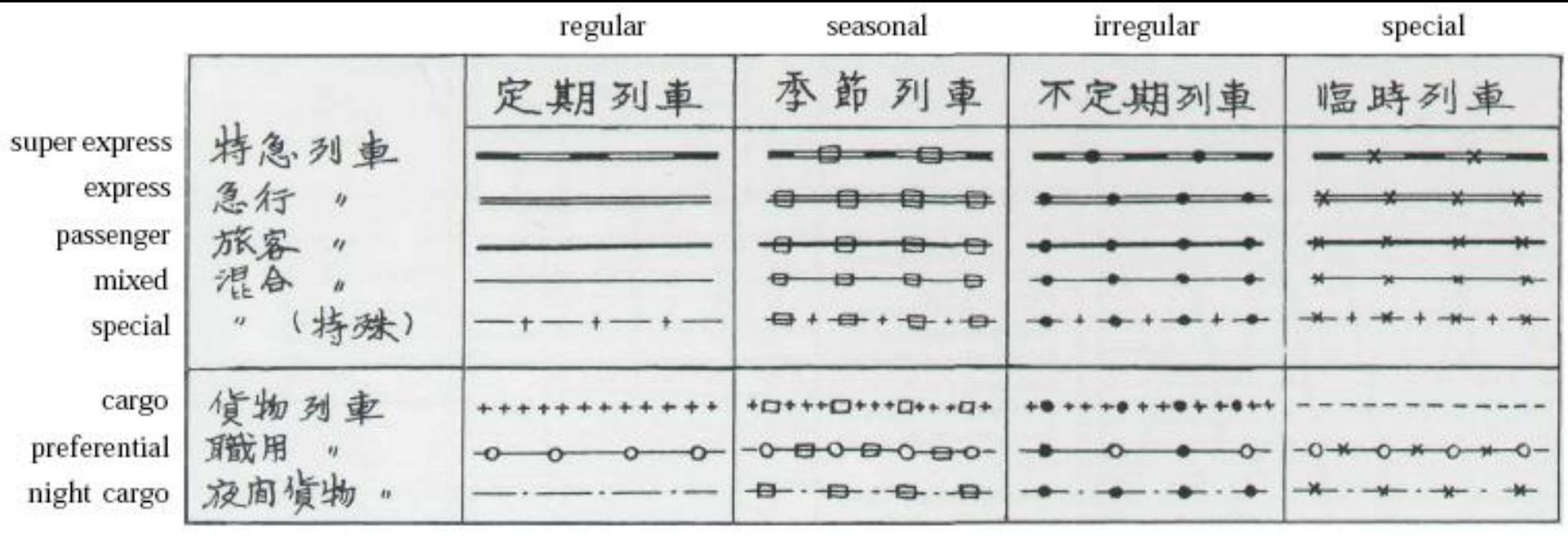


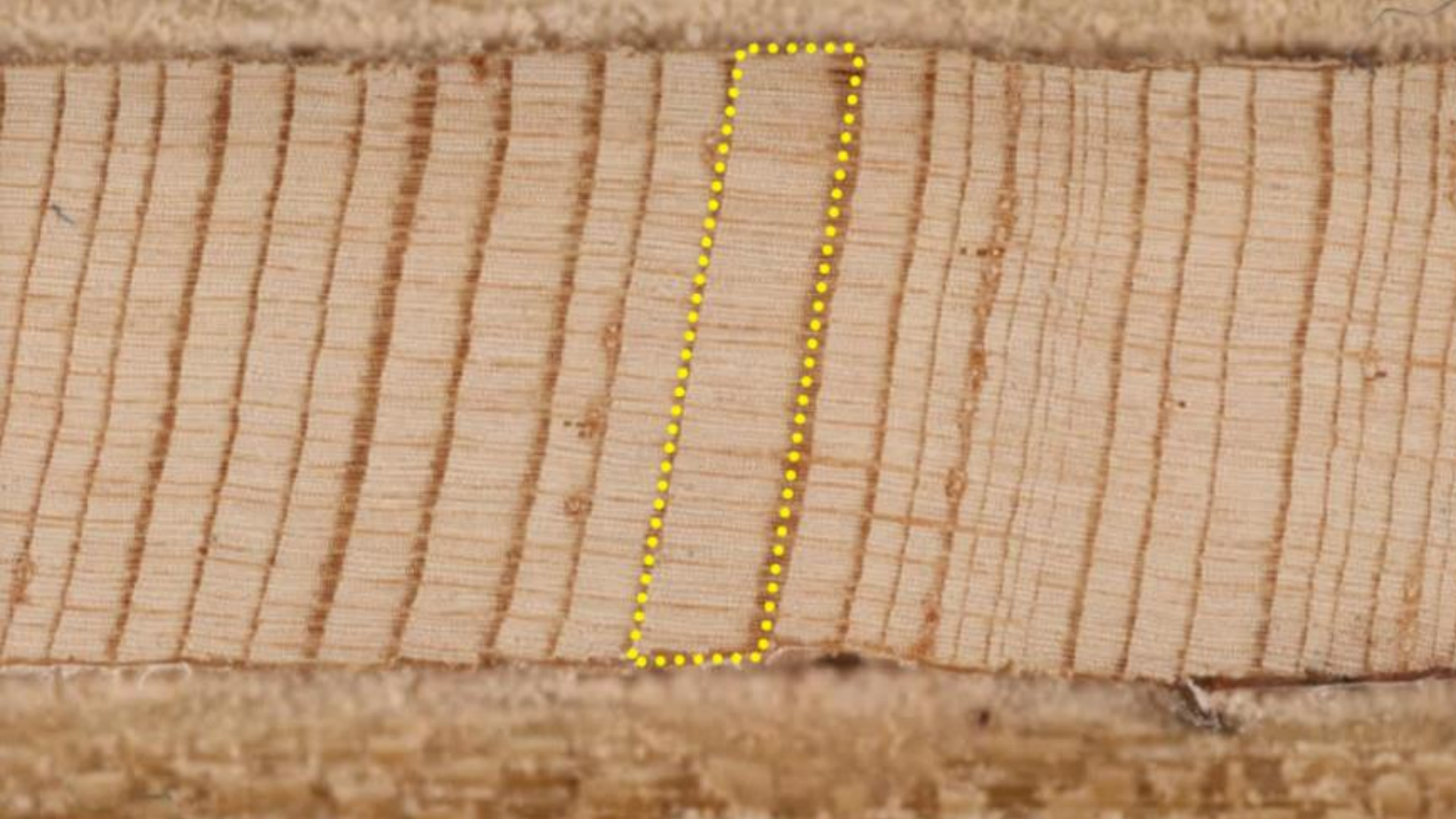



Sb.
Haltbord
Xjsp. Publick on Gasfabriak
sdt
298
337
353
40
Loc


Wo.
Xjsp. B.P.M
zjsp. Ind. Ngagel.
312
405
525
658
89.
40


Sgo.
sdt
648
599
339
425
514
QR.


regular
seasonal
irregular
special
定期列車
季節列車
不定期列車
臨時列車
super express
特急列車
express
急行 〃
passenger
旅客 〃
mixed
混合 〃
special
〃 (特殊)
cargo
貨物列車
preferential
職用 〃
night cargo
夜間貨物 〃




5
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115
120
125
130


12
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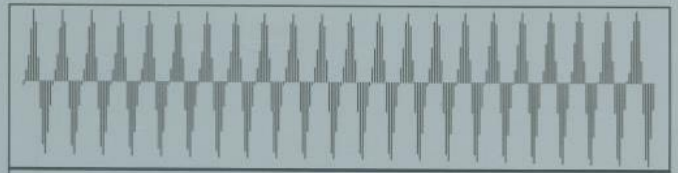
11

How do the human visual & cognitive systems work?

How do humans decode a graph?



The Elements of Graphing Data

William S. Cleveland

Cleveland’s three visual operations of pattern perception:

1. Detection
2. Assembly
3. Estimation

1. Detection

- Detection is the operation of recognizing that a geometric object encodes a physical value

- Detection is the operation of recognizing that a geometric object encodes a physical value

- marks & channels
  - marks: represent items or links
  - channels: change appearance of marks based on attributes

Marks for items

- basic geometric elements

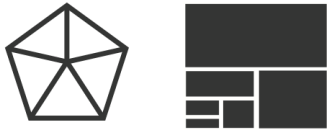
Points

0D

Lines

1D

Interlocking Areas

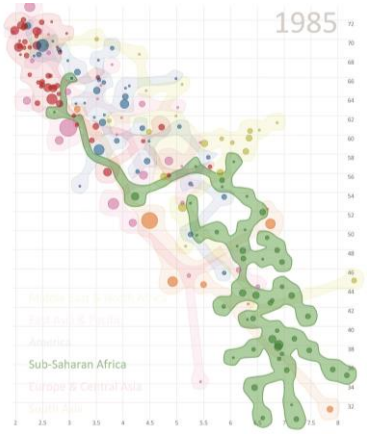


2D

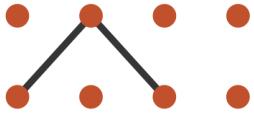
- 3D mark: volume, rarely used

Marks for links

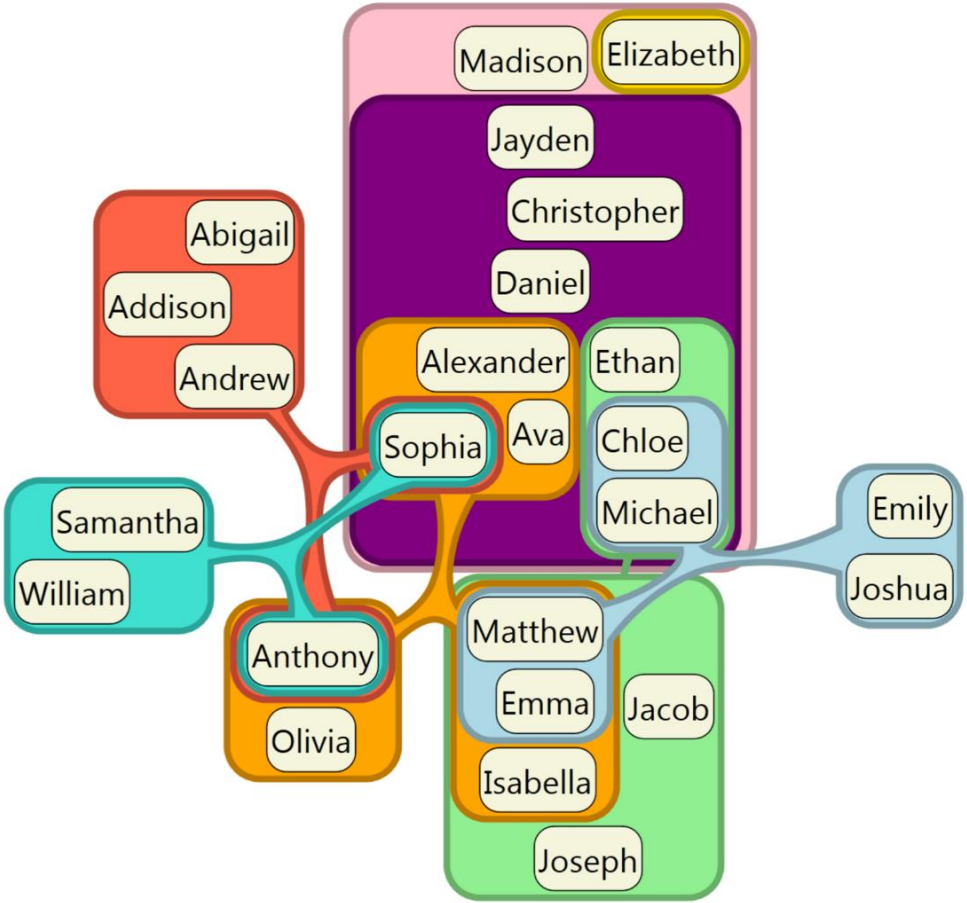
Containment



Connection

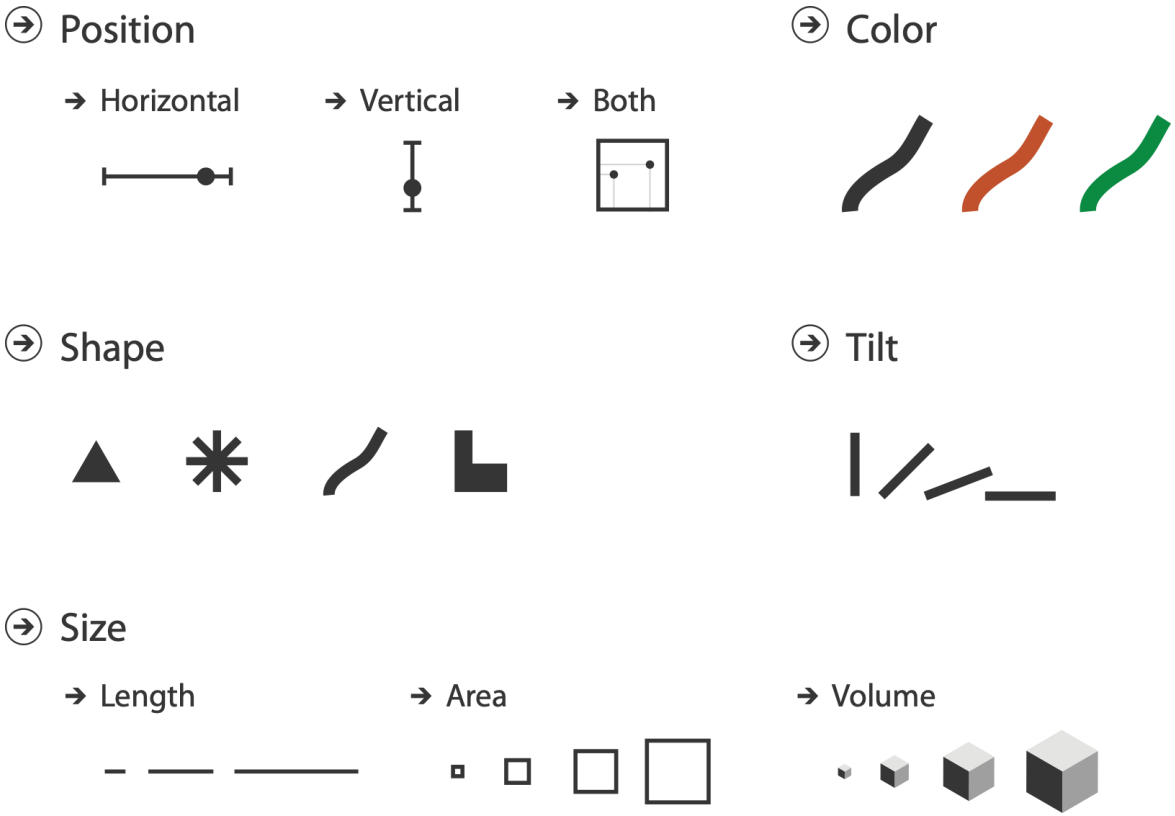


Containment can be nested



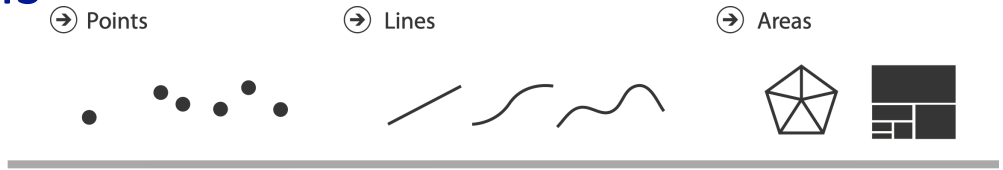
Channels

- control appearance of marks
  - proportional to or based on attributes
- many names
  - **visual channels**
  - visual variables
  - retinal channels
  - visual dimensions
  - …



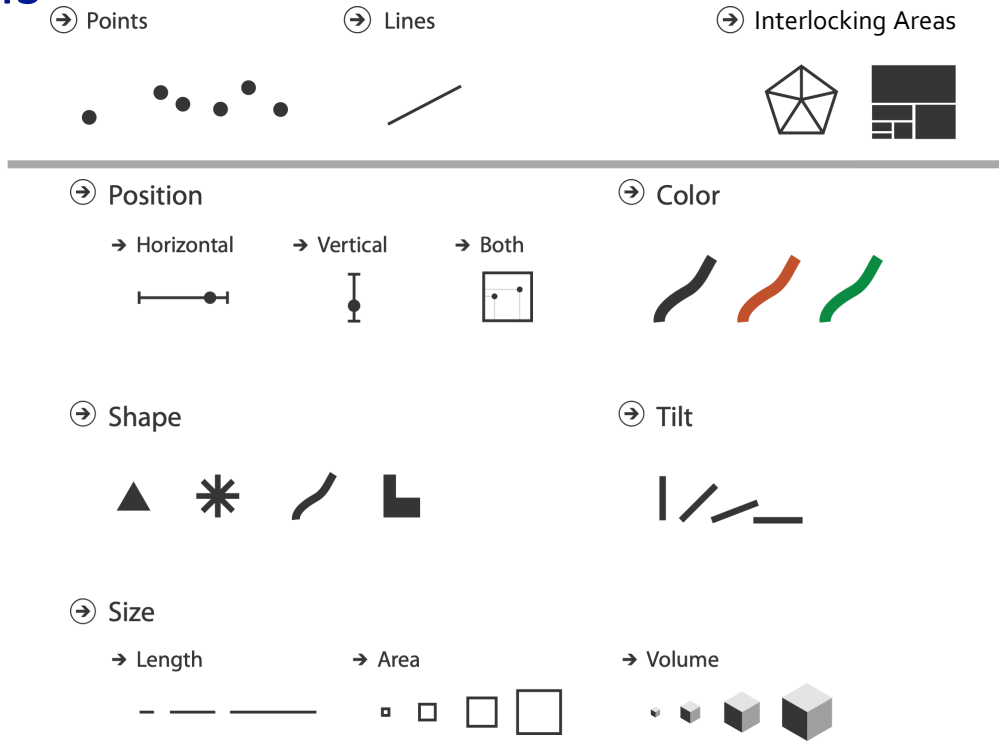
Definitions: Marks and channels

- marks
  - geometric primitives



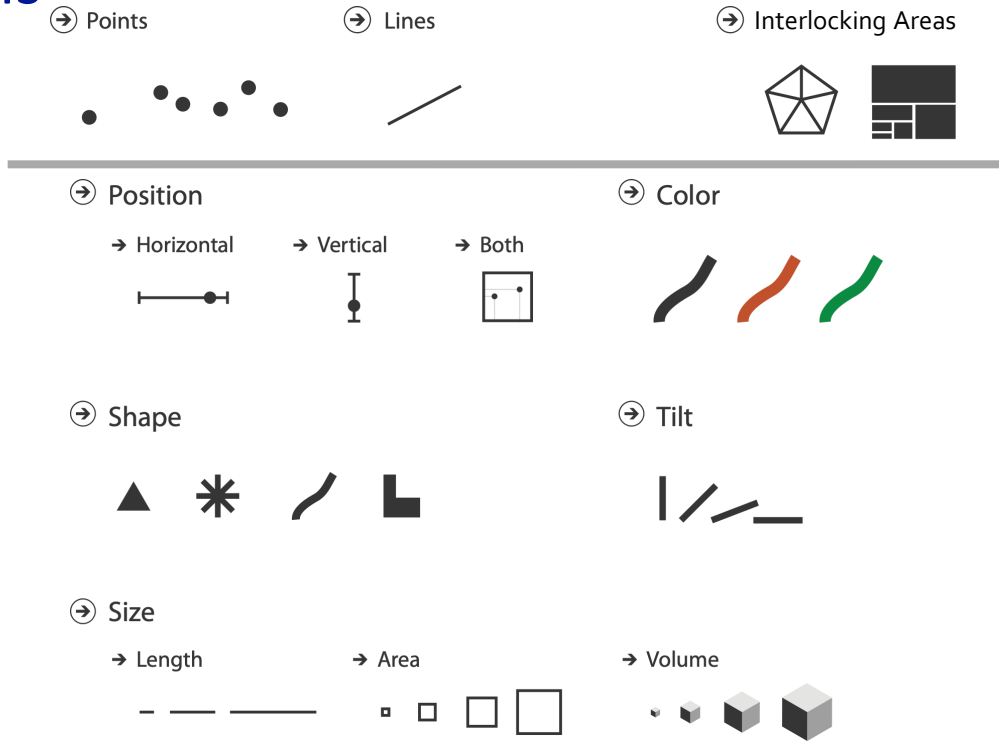
Definitions: Marks and channels

- marks
  - geometric primitives
- channels
  - control appearance of marks



Definitions: Marks and channels

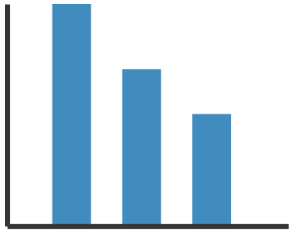
- marks
  - geometric primitives
- channels
  - control appearance of marks
- channel properties differ
  - type & amount of information that can be conveyed to human perceptual system

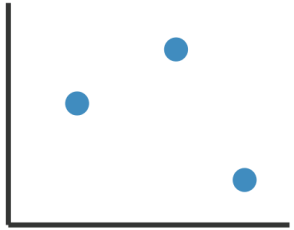


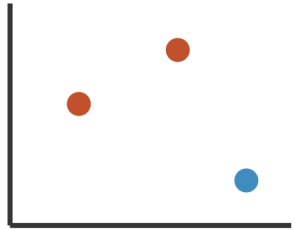
Visual encoding

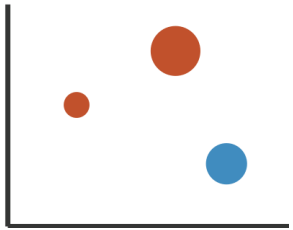
- analyze idiom structure as combination of marks and channels

Visual encoding





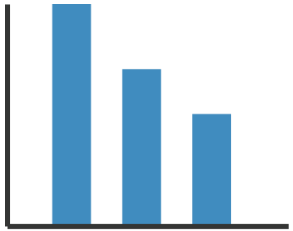




1:
vertical position

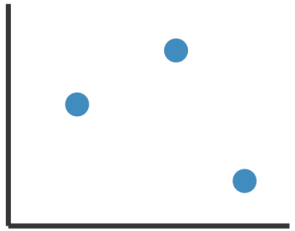
mark: line

Visual encoding



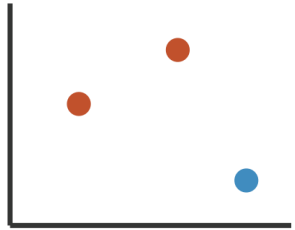
1:
vertical position

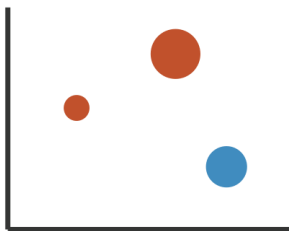
mark: line



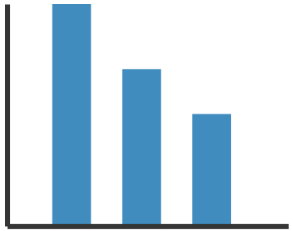
2:
vertical position
horizontal position

mark: line



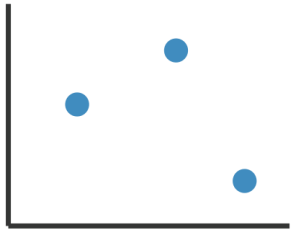


Visual encoding



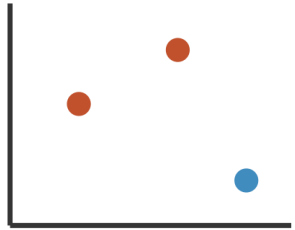
1:
vertical position

mark: line



2:
vertical position
horizontal position

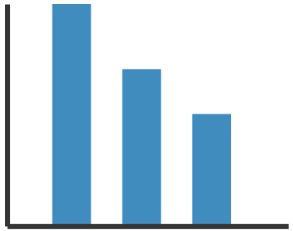
mark: line



3:
vertical position
horizontal position
colour hue

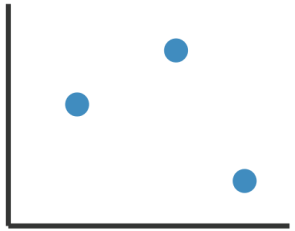
mark: line

Visual encoding



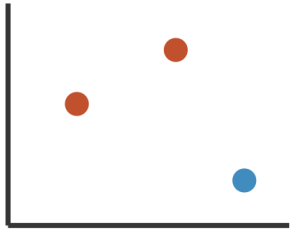
1:
vertical position

mark: line



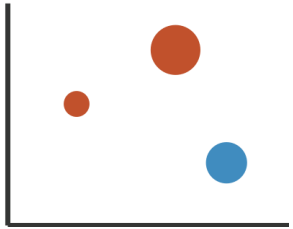
2:
vertical position
horizontal position

mark: line



3:
vertical position
horizontal position
colour hue

mark: line

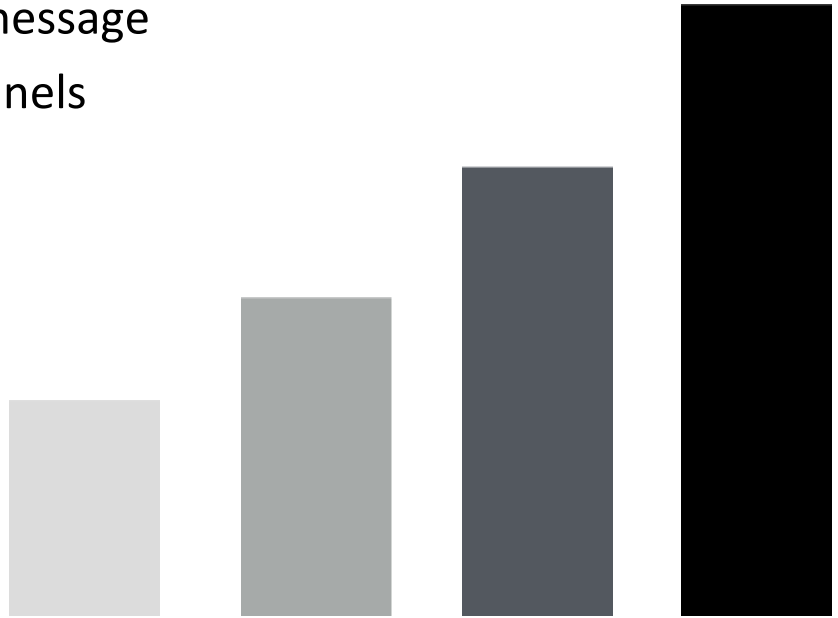


4:
vertical position
horizontal position
colour hue
size (area)

mark: line

Redundant encoding

- multiple channels
  - sends stronger message
  - but uses up channels



The Eye

- 70% of body's sense receptors reside in our eyes
- The eye and the visual cortex of the brain form a massively parallel processor that provides the highest-bandwidth channel into human cognitive centers."
  — Colin Ware, Information Visualization, 2004
- Important to understand how visual perception works in order to effectively design visualizations

The Eye

- The eye is not a camera!
- Better metaphor for vision: “dynamic and ongoing construction project"
  — Healey, 1995
- Attention is selective (Filtering)

The Eye

- **Cameras**
  — Good optics
  — Single focus, white balance, exposure
  — “Full image capture“

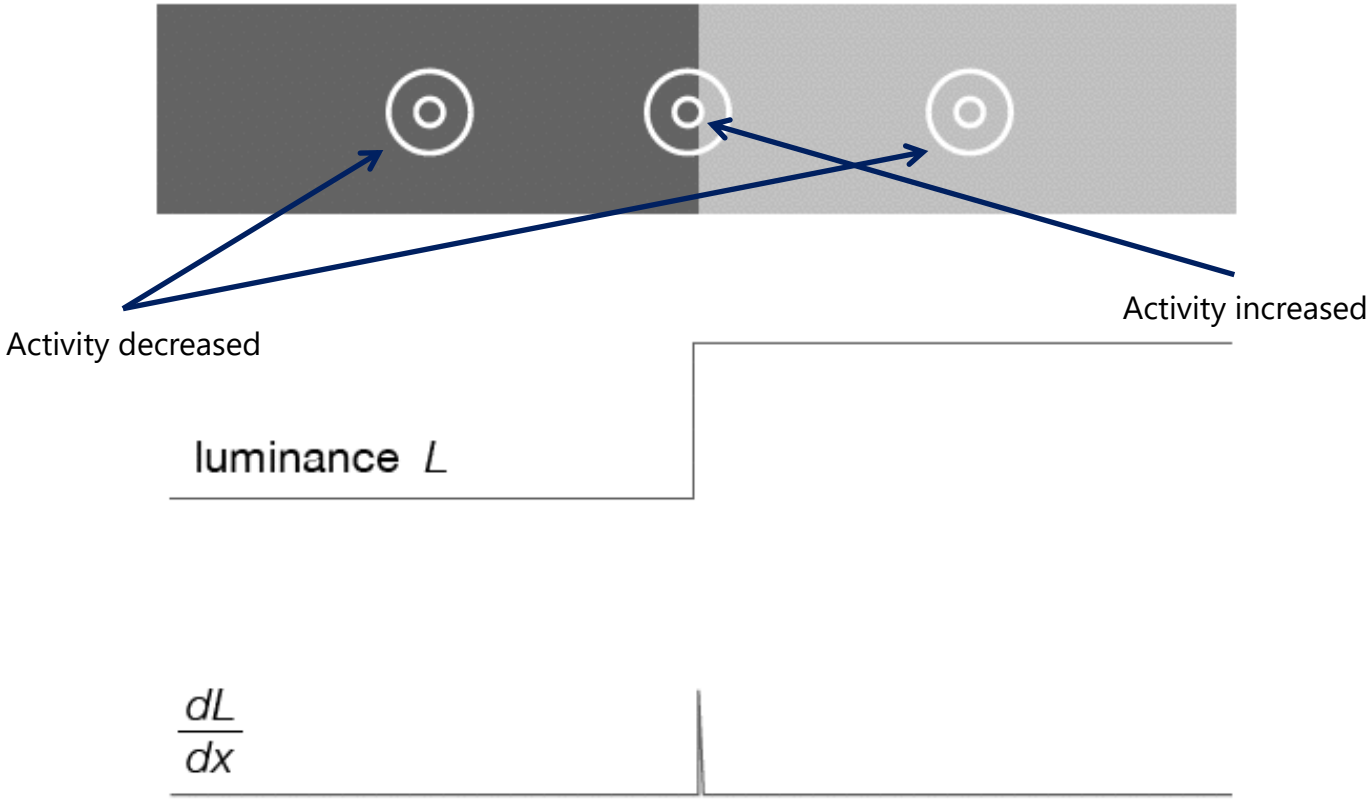
- **Eyes**
  — Relatively poor optics
  — Constantly scanning (saccades)
  — Constantly adjusting focus
  — Constantly adapting
  — Mental reconstruction of image

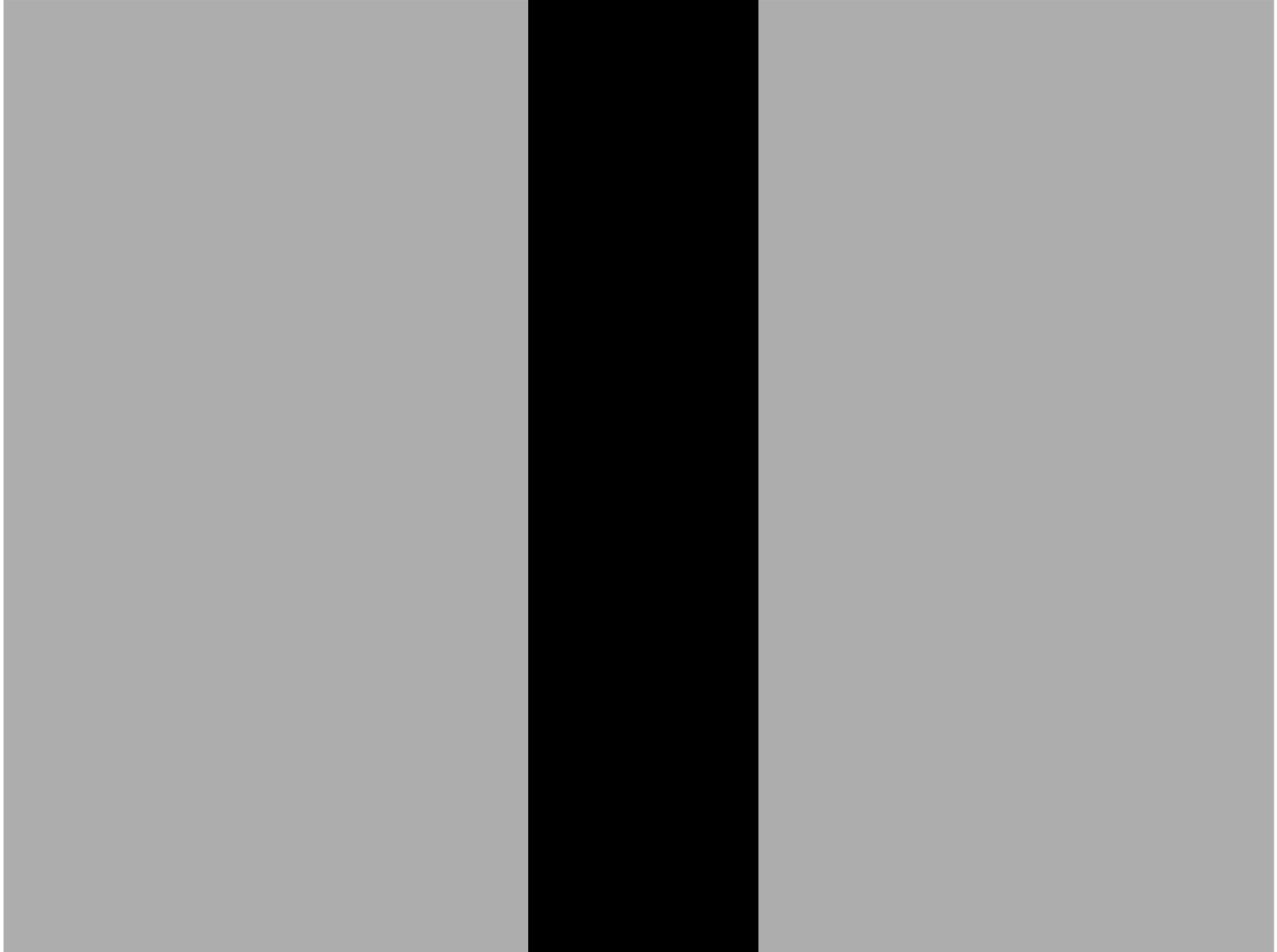
How the eye detects information

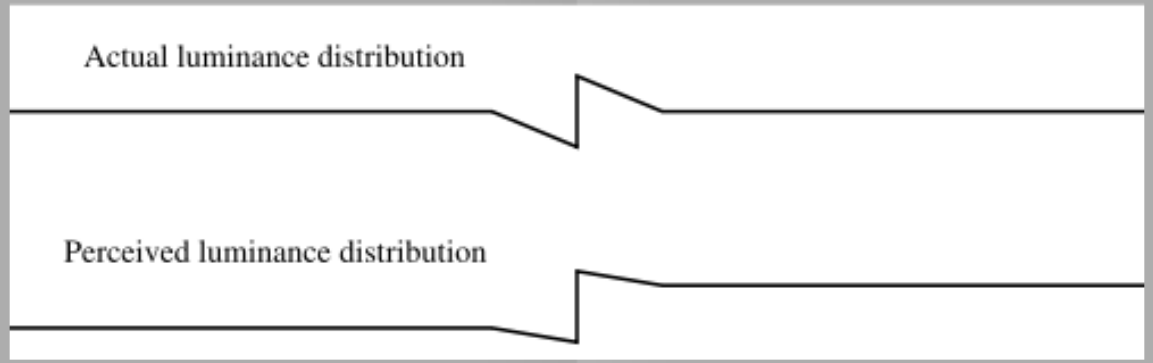
- Our visual system sees differences, not absolute values, and is attracted to edges.
- Maximize the contrast with the background if the outlines of shapes are important.
- Our visual system constructs surface colour based largely on edge contrast information.
- We have higher contrast sensitivity in the luminance than in the chrominance channel.
- Our visual system corrects (misreads) information based on perceived visual properties

The Eye – Edge detection

The Eye – Edge detection

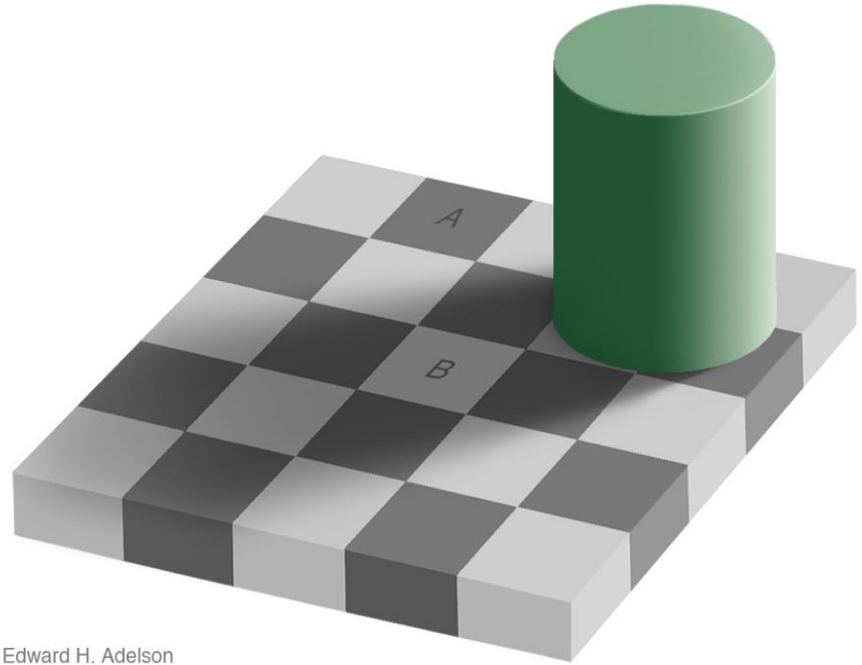





Actual luminance distribution
Perceived luminance distribution

Relative luminance judgements

- perception of luminance is contextual based on contrast with surroundings

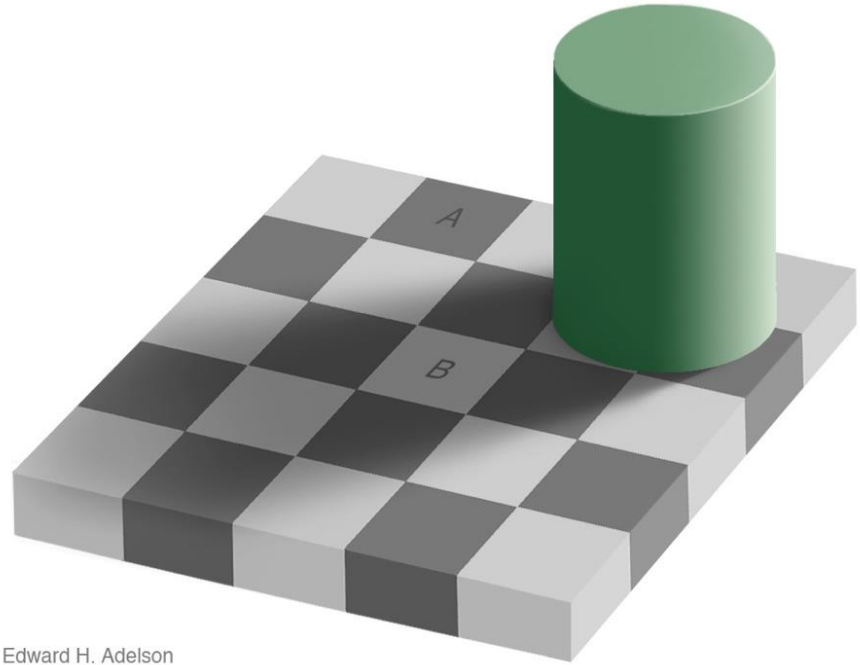


Edward H. Adelson

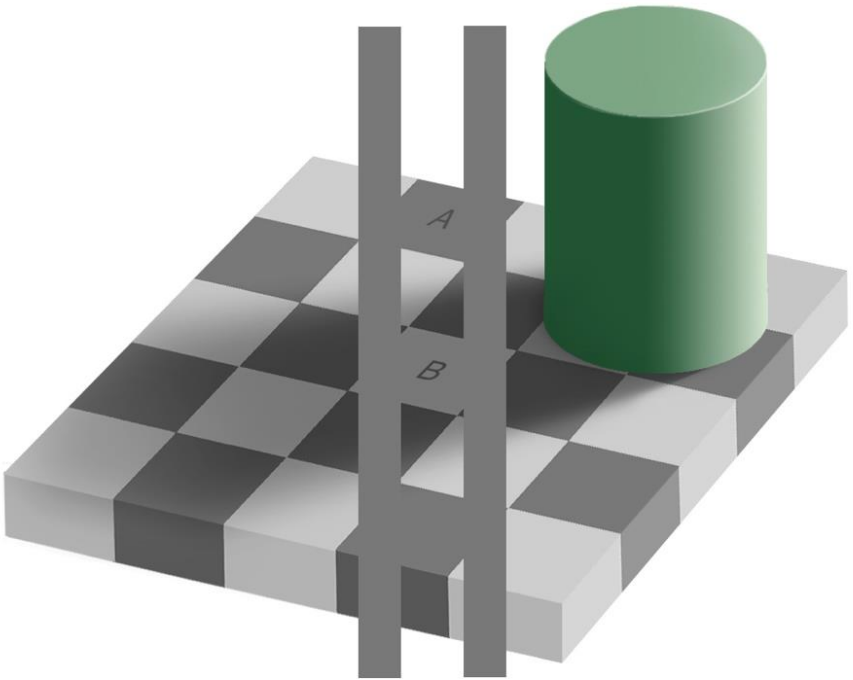
http://persci.mit.edu/gallery/checkershadow

Relative luminance judgements

- perception of luminance is contextual based on contrast with surroundings



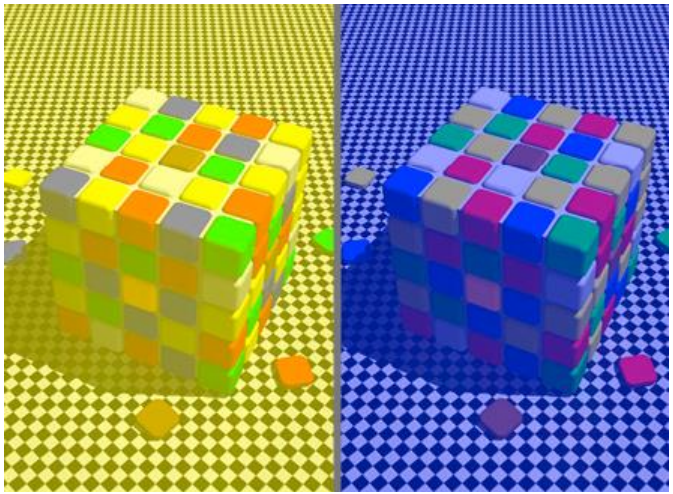
Edward H. Adelson



http://persci.mit.edu/gallery/checkershadow

Relative color judgements

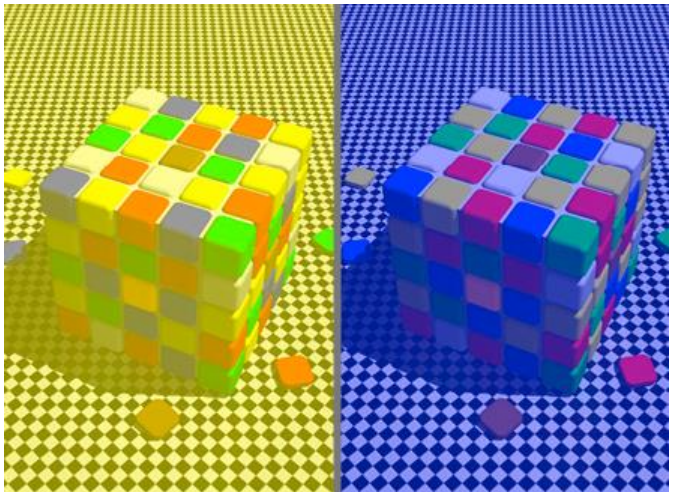
- color constancy across broad range of illumination conditions

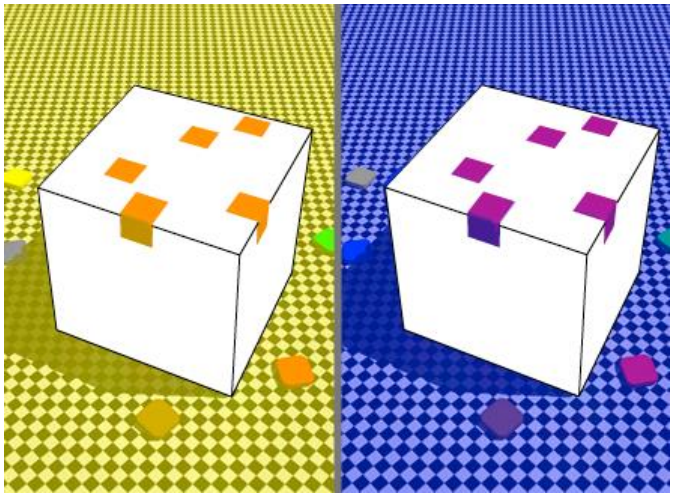


http://www.purveslab.net/seeforyourself/

Relative color judgements

- color constancy across broad range of illumination conditions





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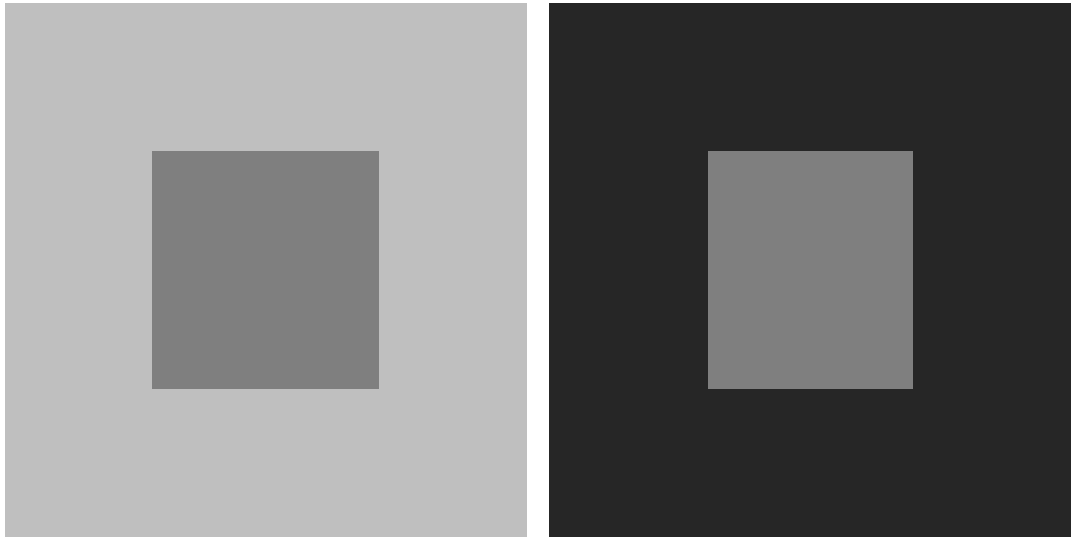
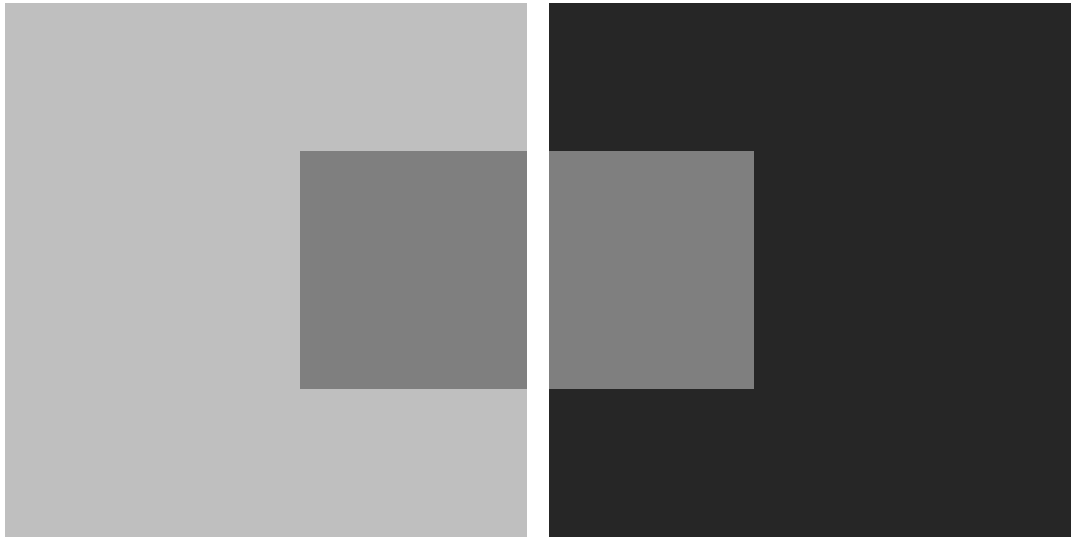
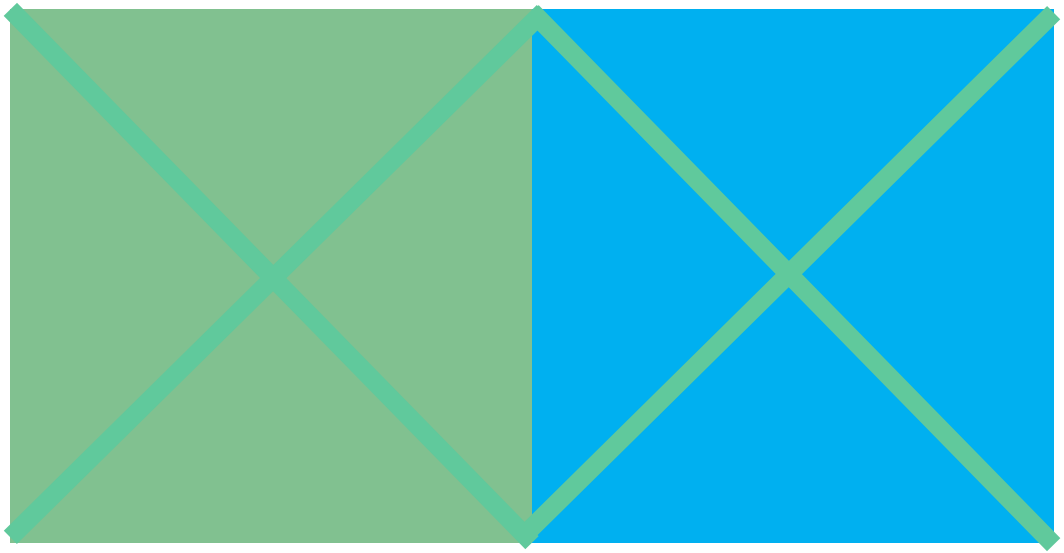
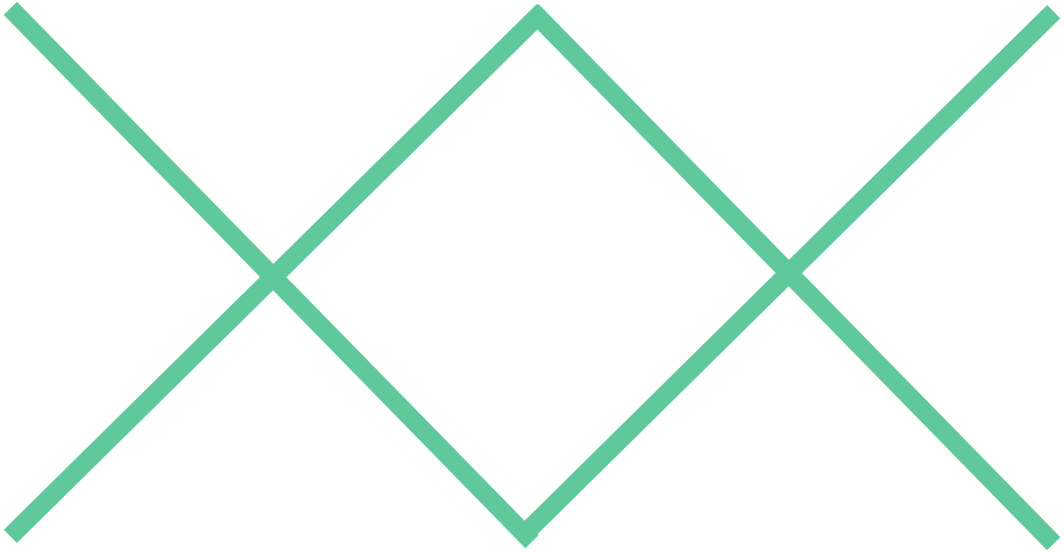
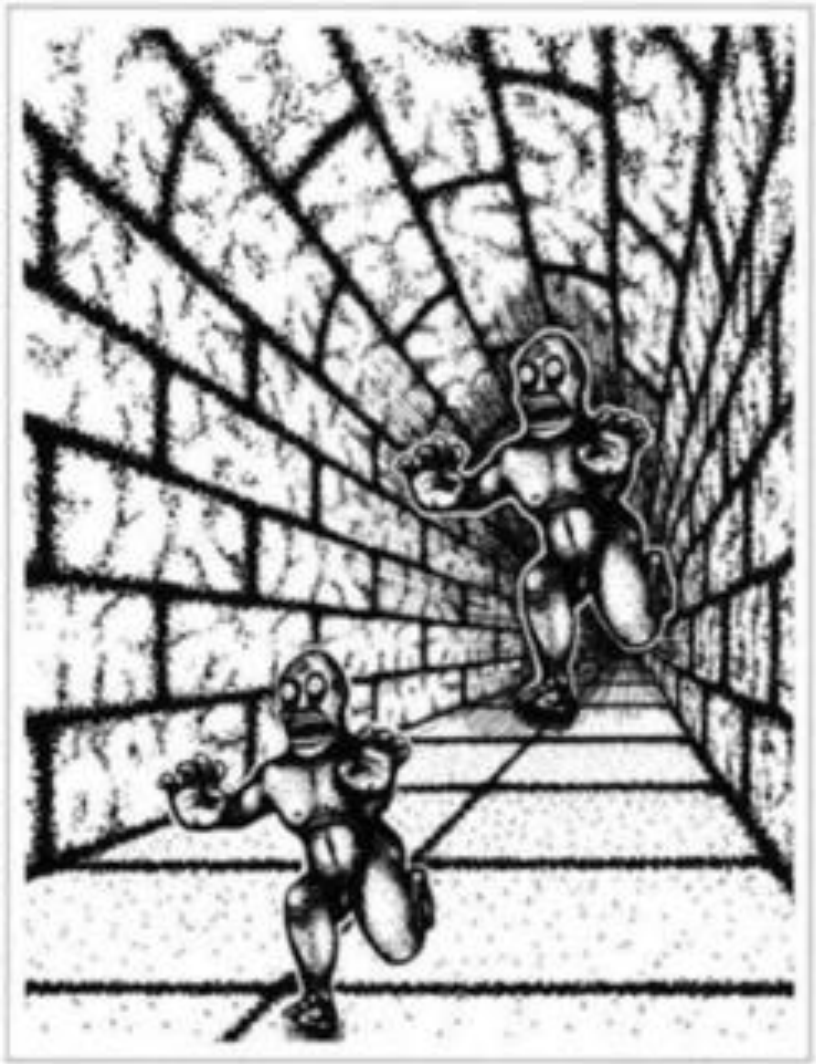
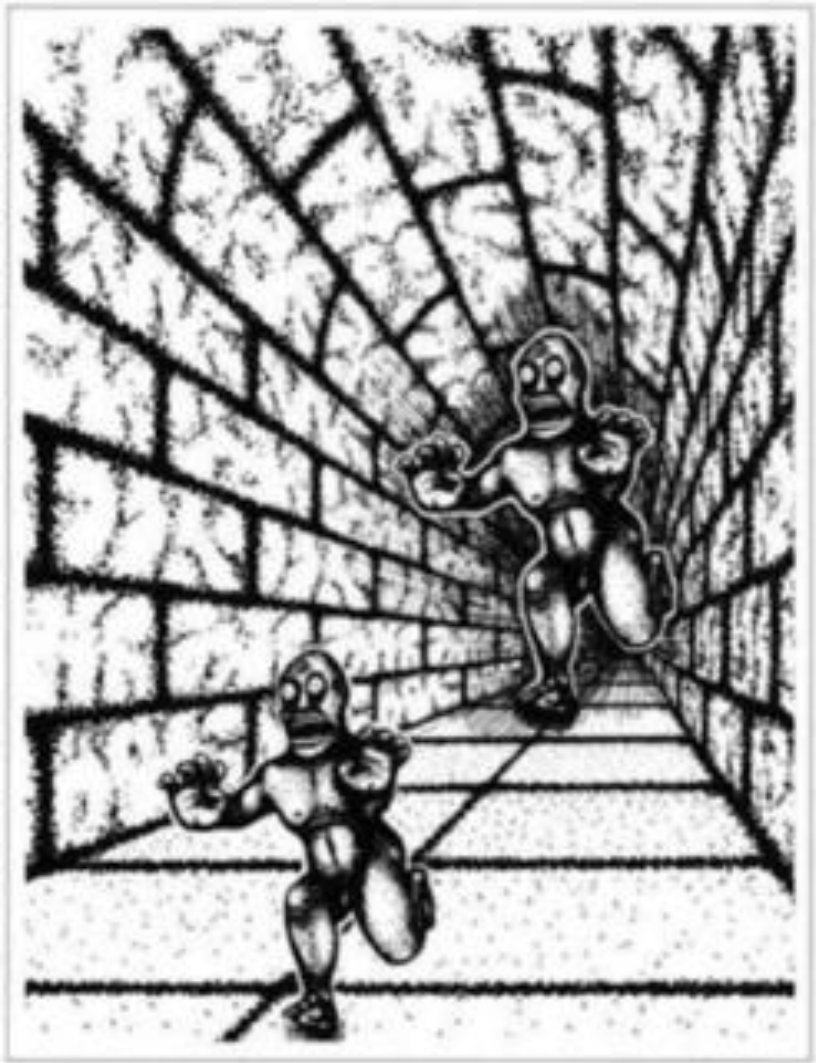


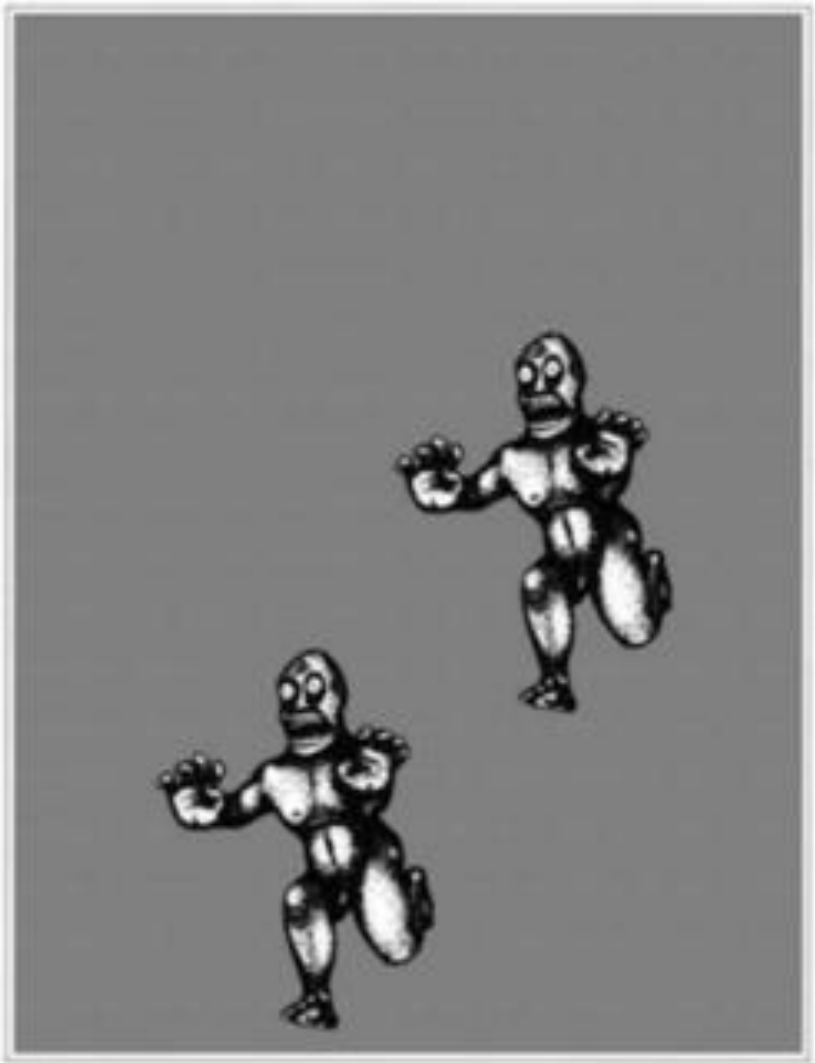












Cleveland’s three visual operations of pattern perception:

1. Detection
2. Assembly
3. Estimation

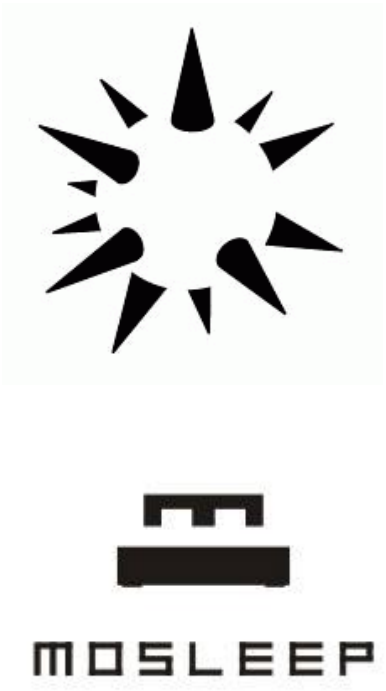
2. Assembly

Gestalt psychology of perceptual organisation

- Based on the work of Kurt Koffka, Max Wertheimer, and Wolfgang Köhler
- Law of Prägnanz (pithiness, goodness)
- Things are organized spontaneously and assumed to be in the simplest configuration
- Perception as organized and structured wholes rather than the sum of their constituent parts
- Emergent, holistic, interdependent, and in context

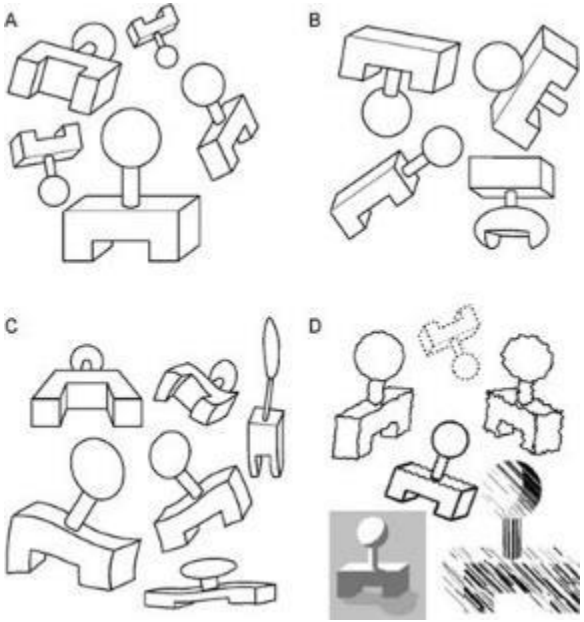
The gestalt laws of perceptual organization

1. Emergence: The mind sees the whole and then the parts. It often sees more than what is specifically stated by its individual parts.



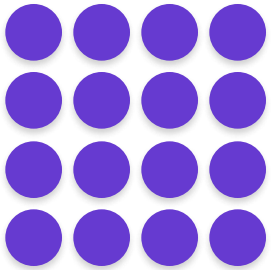
The gestalt laws of perceptual organization

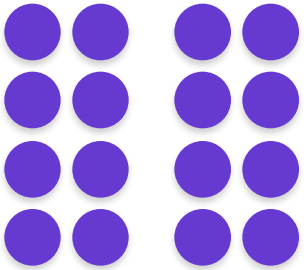
2. Invariance: The mind recognizes simple objects independent of rotation, translation, scale, deformations and lighting

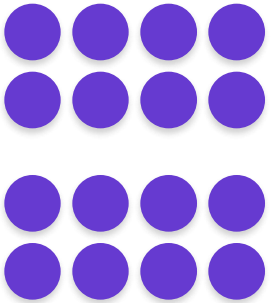


The gestalt laws of perceptual organization

3. Proximity: Elements that are closer together are perceived to be more related than elements that are farther apart





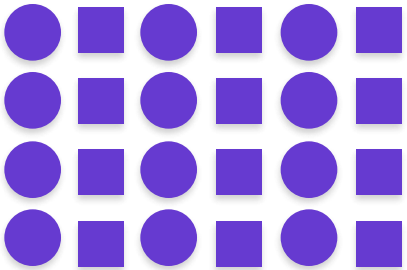


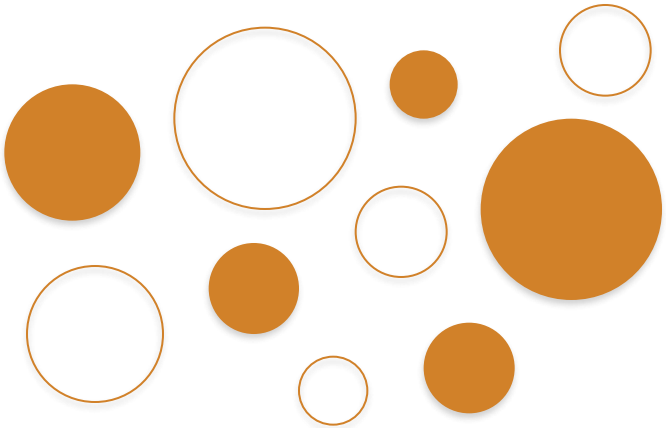
The gestalt laws of perceptual organization

3. Proximity: Elements that are closer together are perceived to be more related than elements that are farther apart

The gestalt laws of perceptual organization

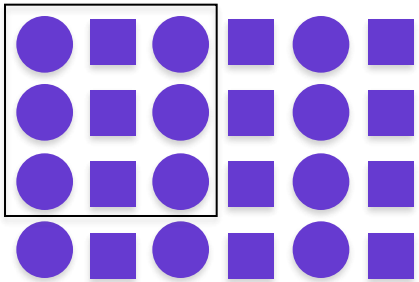
4. Similarity: Elements that are similar are perceived to be more related than elements that are dissimilar





The gestalt laws of perceptual organization

5. Enclosure: Elements that are enclosed by anything are perceived as belonging together

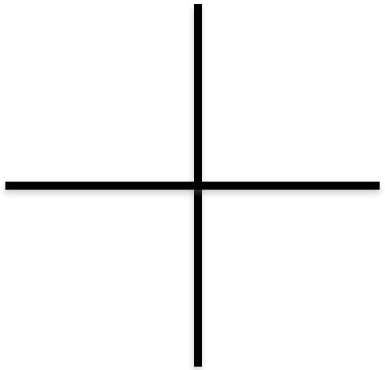


The gestalt laws of perceptual organization

5. Enclosure: Elements that are enclosed by anything are perceived as belonging together

The gestalt laws of perceptual organization

6. Continuity: The mind continues visual, auditory, and kinetic patterns



The gestalt laws of perceptual organization

6. Continuity: The mind continues visual, auditory, and kinetic patterns

The gestalt laws of perceptual organization

7. Closure: The mind perceives a set of individual elements as a single, recognizable pattern

The gestalt laws of perceptual organization

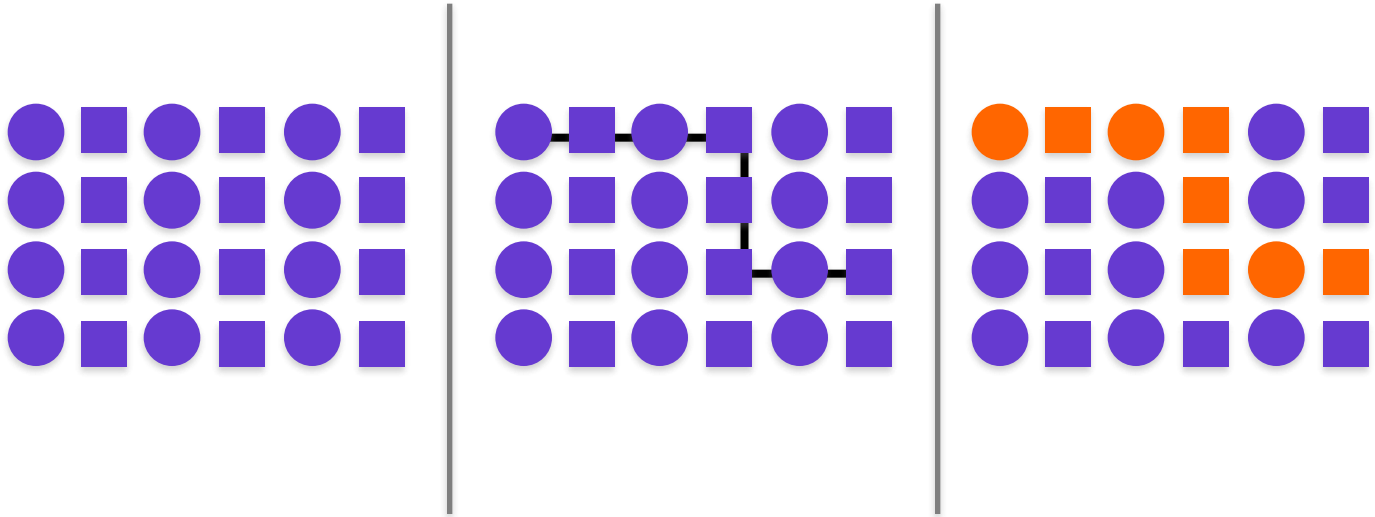
7. Symmetry: The mind perceives objects as symmetrical shapes that form around their center

The gestalt laws of perceptual organization

8. Figure-ground: Elements are perceived as either figures (objects of focus) or ground (the rest of the perceptual field)

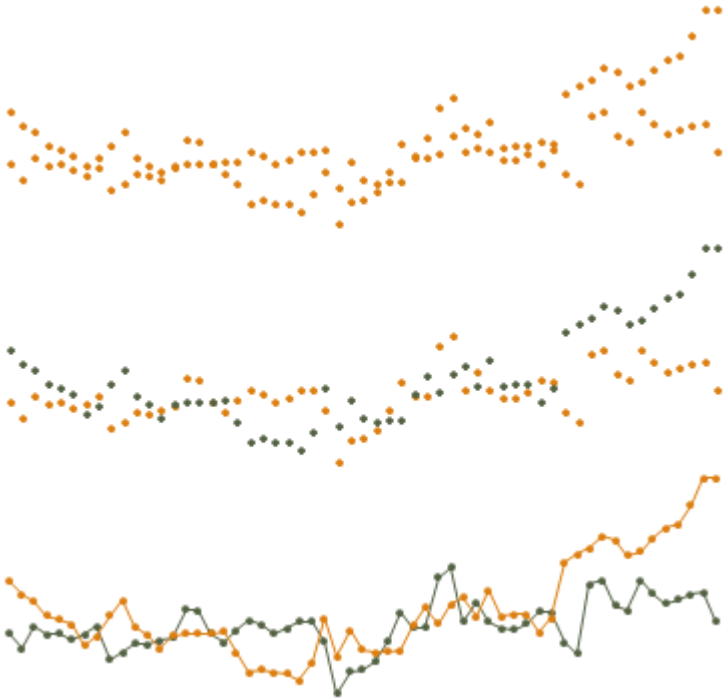
The gestalt laws of perceptual organization

9. Connection: Elements that are connected (e.g. by a line) are perceived as belonging together



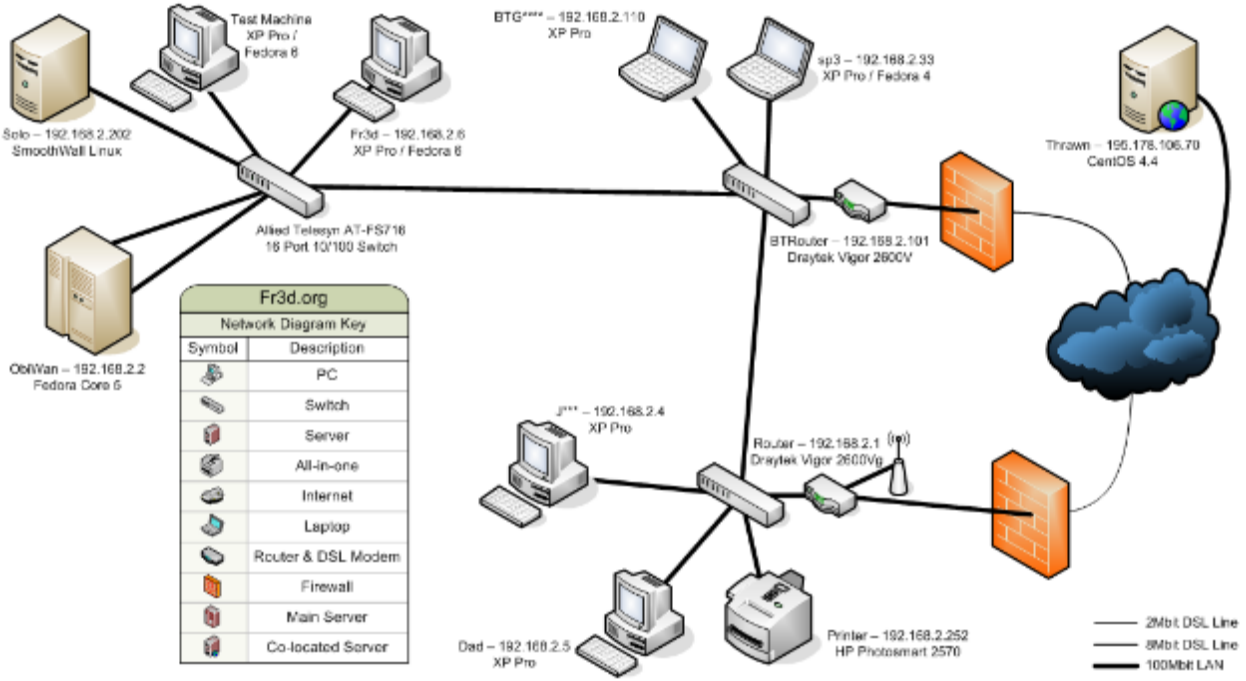
The gestalt laws of perceptual organization

9. Connection: Elements that are connected (e.g. by a line) are perceived as belonging together



The gestalt laws of perceptual organization

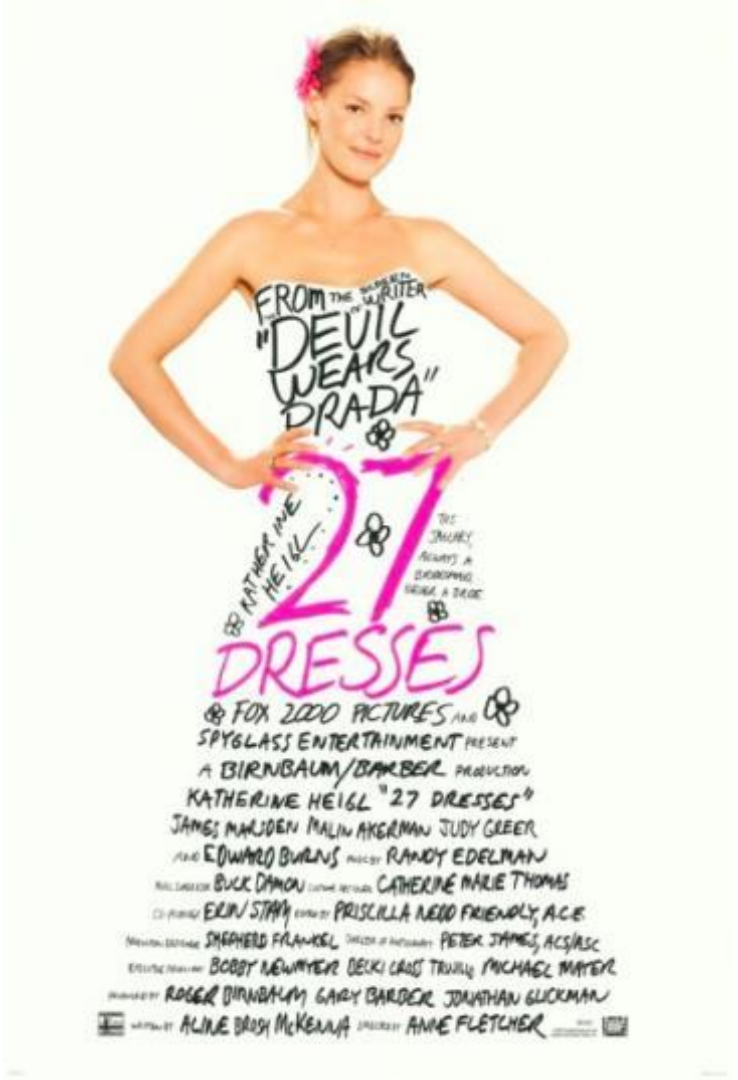
9. Connection: Elements that are connected (e.g. by a line) are perceived as belonging together



The gestalt laws of perceptual organization

10. Common-fate: Elements that share a common fate (e.g., moving in the same direction) as belonging together

Edward Weston, 1886-1958

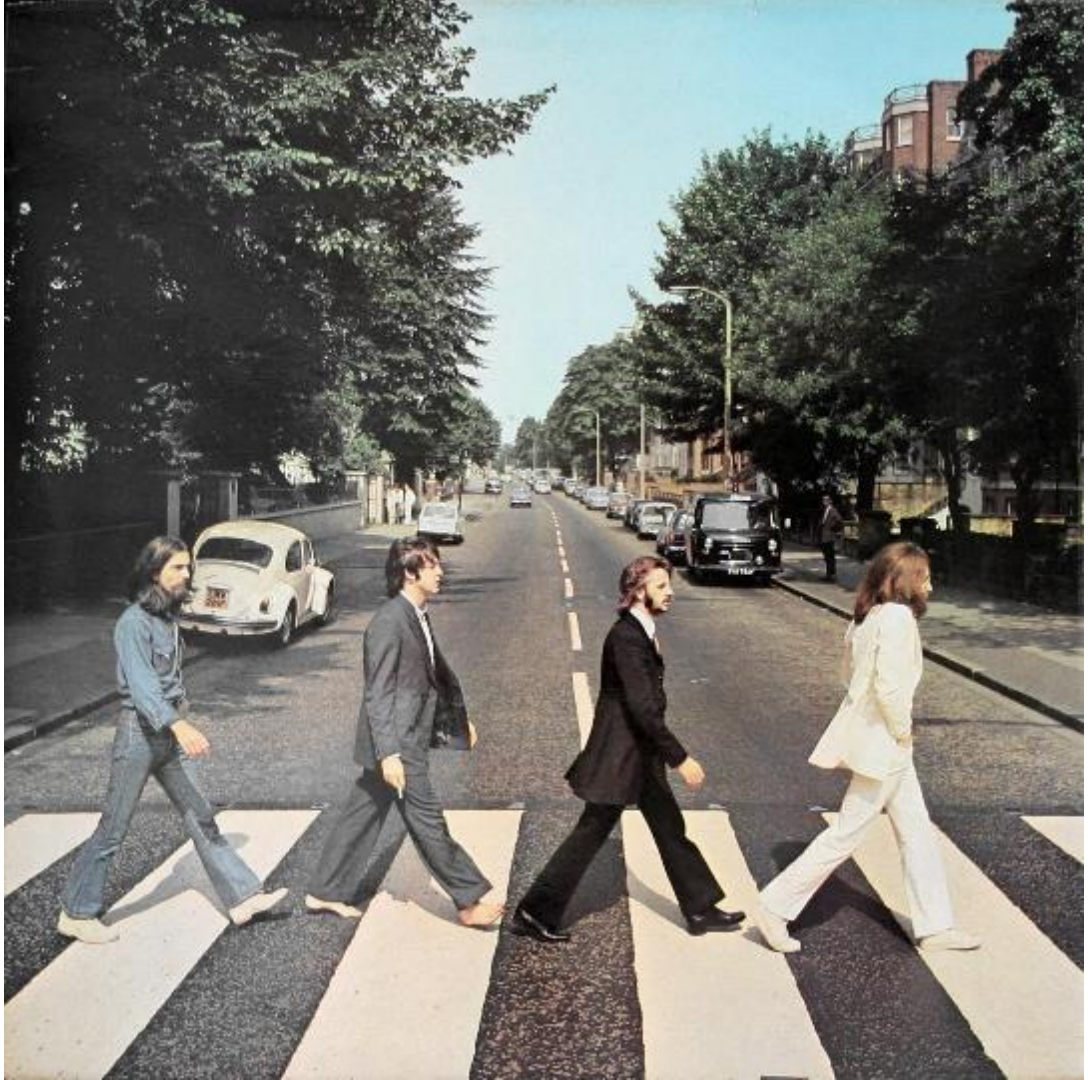

FROM THE SCREEN WRITER OF "DEVIL WEARS PRADA"
RATHER HAVE HE 16L
27
DRESSES
FOX 2000 PICTURES AND SPYGLASS ENTERTAINMENT PRESENT
A BIRNBAUM/BARBER PRODUCTION
KATHERINE HEIGL "27 DRESSES"
JAMES MARSDEN MALIN AKERMAN JUDY GREER
EDWARD BURNS
RANDY EDELMAN
BUCK DAMON
CATHERINE MARIE THOMAS
ERIN STARK
PRISCILLA NEDD FRIENDLY, A.C.E.
SHEPHERD FRANKEL
PETER JAMES, ACS/ASC
BOBBY NEWMYER
BECKI CROSS TRUHN
MICHAEL MAYER
ROGER BIRNBAUM GARY BARBER JONATHAN GLICKMAN
ALINE BROSH MCKENNA
ANNE FLETCHER


LIMA
MOROCOCHA

The Creation of Adam by Michelangelo, fresco Sistine chapel, 1512

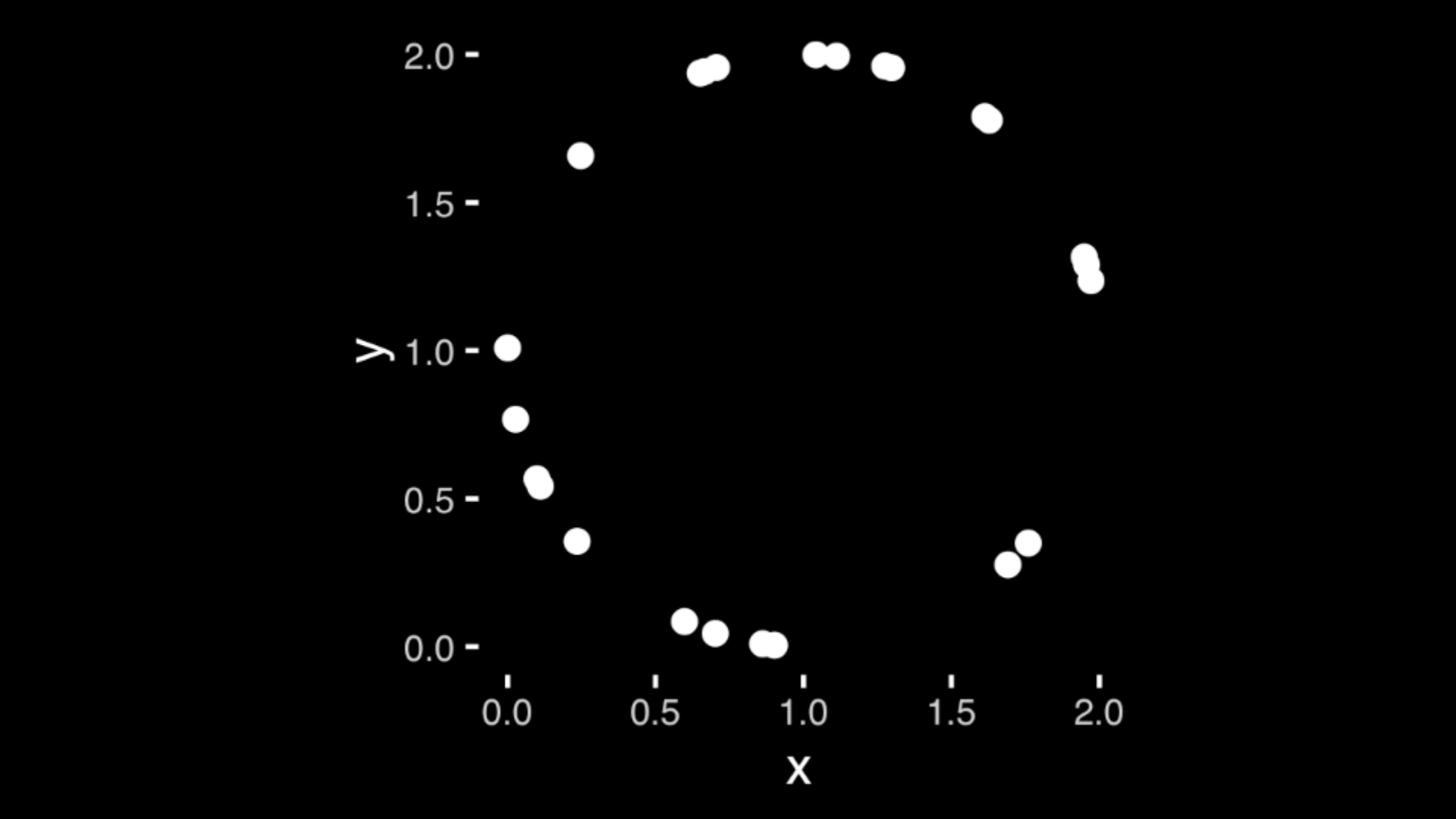
Marc Riboud, 1923-

Portrait of Adele Bloch-Bauer.
1907
by Guastav Klimt



Marc Riboud, 1923-


III-51
M.C. Escher NS 48/50
cujendruk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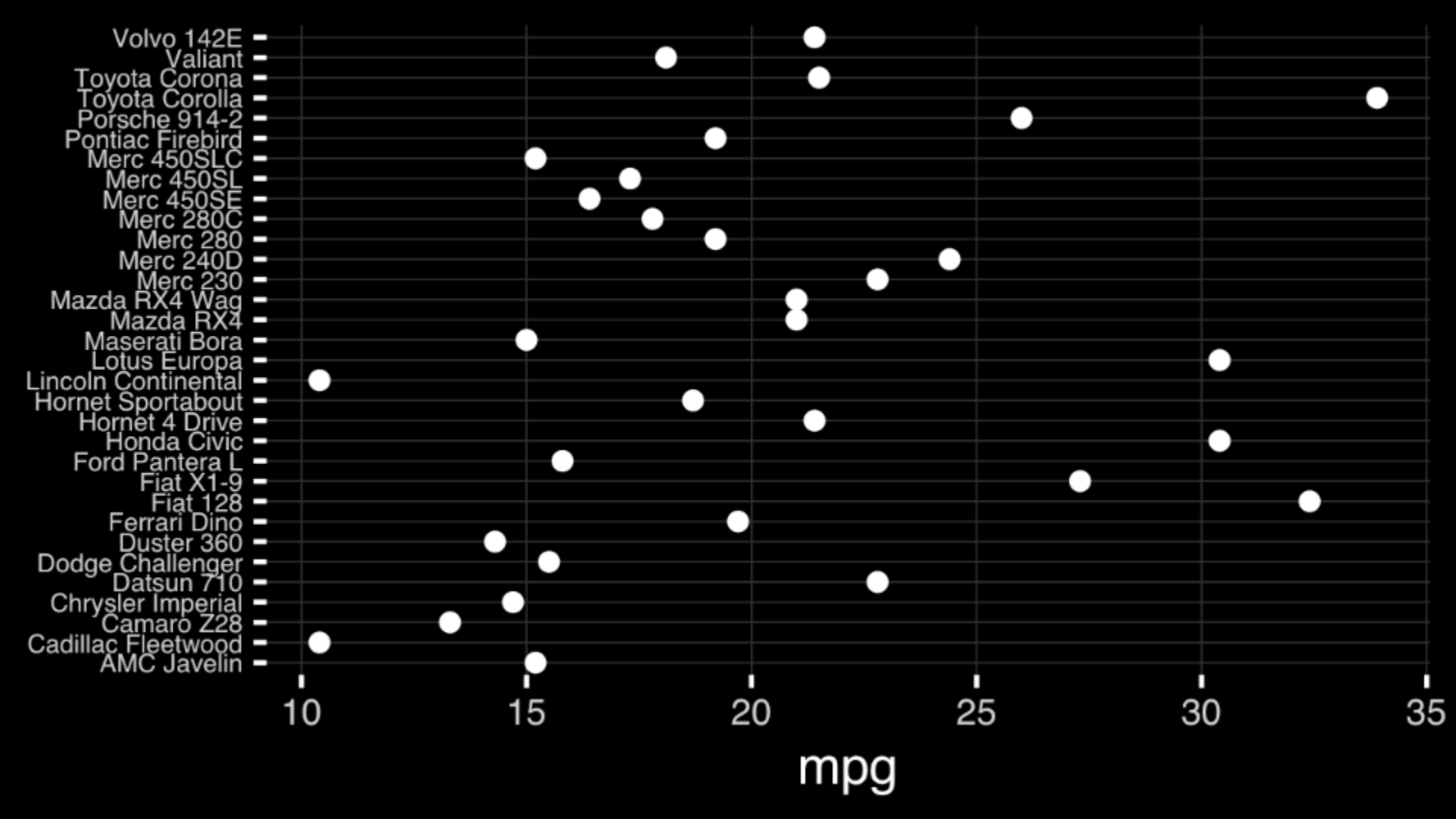
Law Of Continuity


Volvo 142E
Valiant
Toyota Corona
Toyota Corolla
Porsche 914-2
Pontiac Firebird
Merc 450SLC
Merc 450SL
Merc 450SE
Merc 280C
Merc 280
Merc 240D
Merc 230
Mazda RX4 Wag
Mazda RX4
Maserati Bora
Lotus Europa
Lincoln Continental
Hornet Sportabout
Hornet 4 Drive
Honda Civic
Ford Pantera L
Fiat X1-9
Fiat 128
Ferrari Dino
Duster 360
Dodge Challenger
Datsun 710
Chrysler Imperial
Camaro Z28
Cadillac Fleetwood
AMC Javelin
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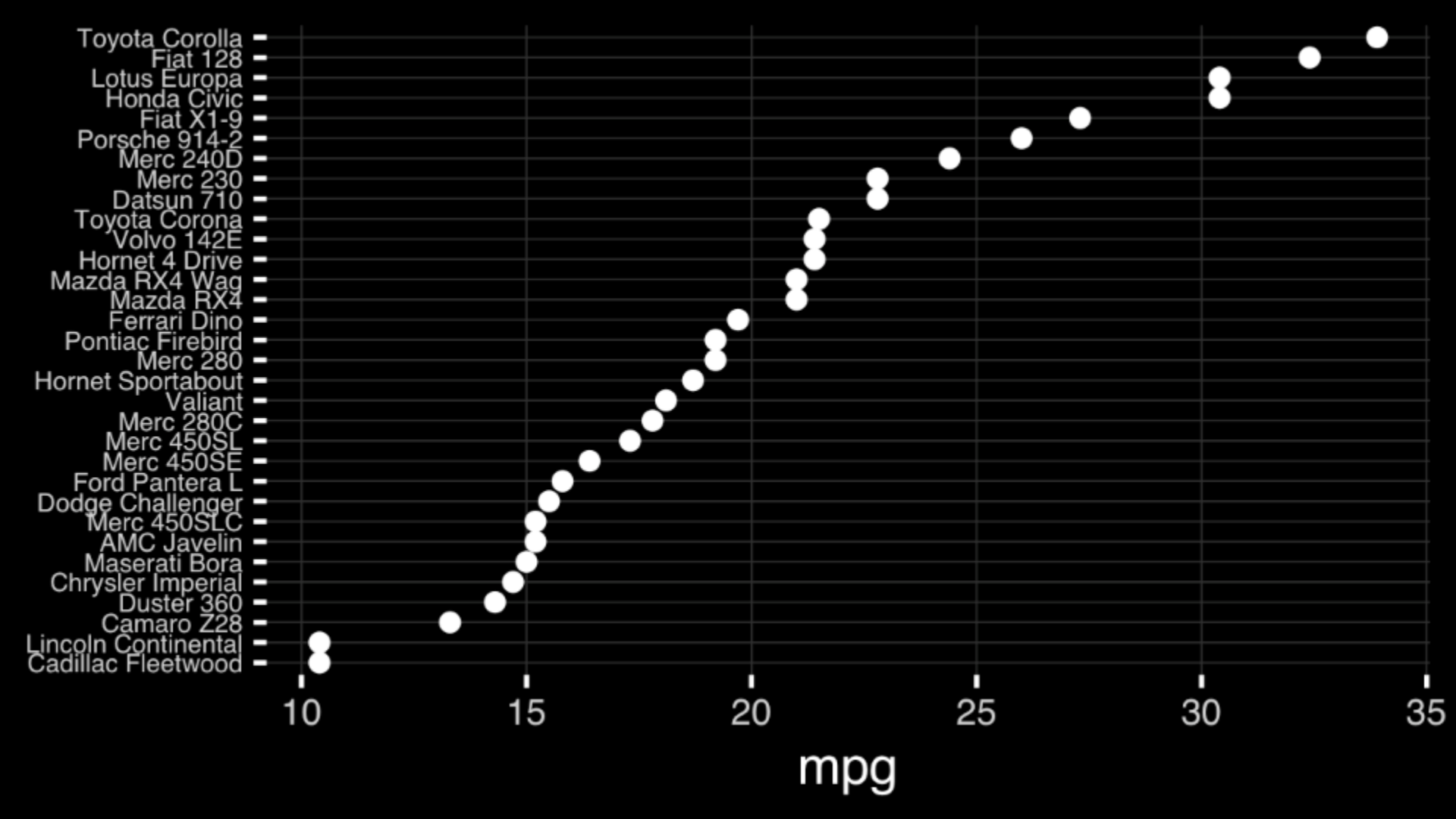
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Fiat 128
Lotus Europa
Honda Civic
Fiat X1-9
Porsche 914-2
Merc 240D
Merc 230
Datsun 710
Toyota Corona
Volvo 142E
Hornet 4 Drive
Mazda RX4 Wag
Mazda RX4
Ferrari Dino
Pontiac Firebird
Merc 280
Hornet Sportabout
Valiant
Merc 280C
Merc 450SL
Merc 450SE
Ford Pantera L
Dodge Challenger
Merc 450SLC
AMC Javelin
Maserati Bora
Chrysler Imperial
Duster 360
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Lincoln Continental
Cadillac Fleetwood
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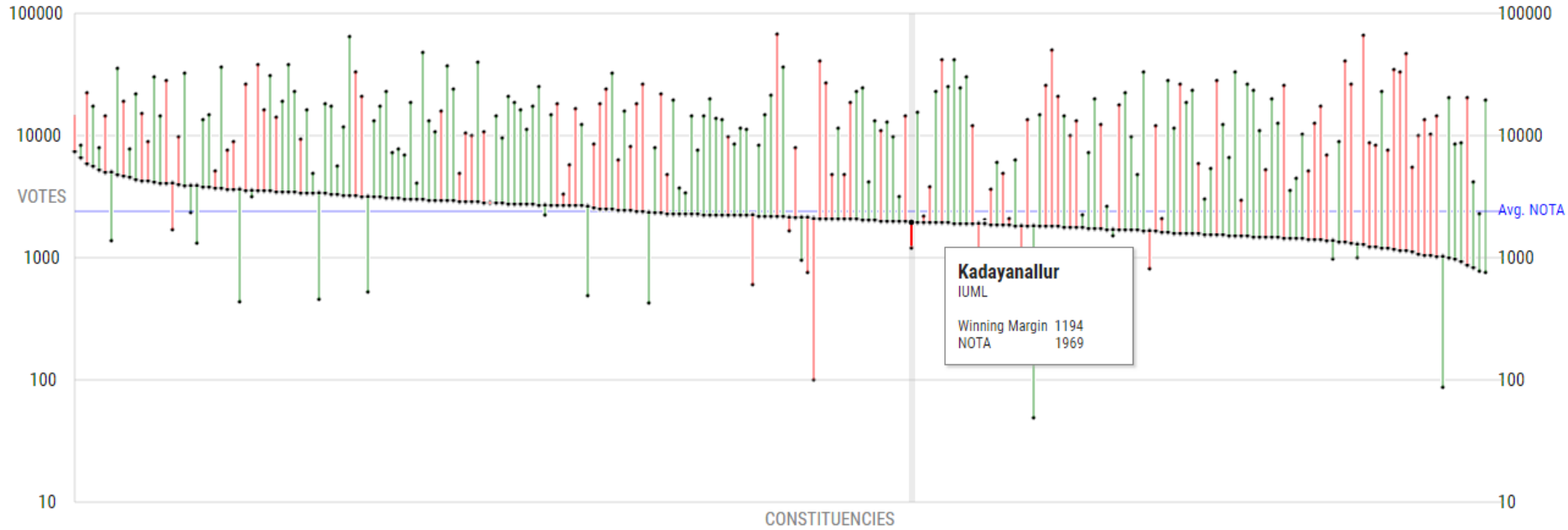
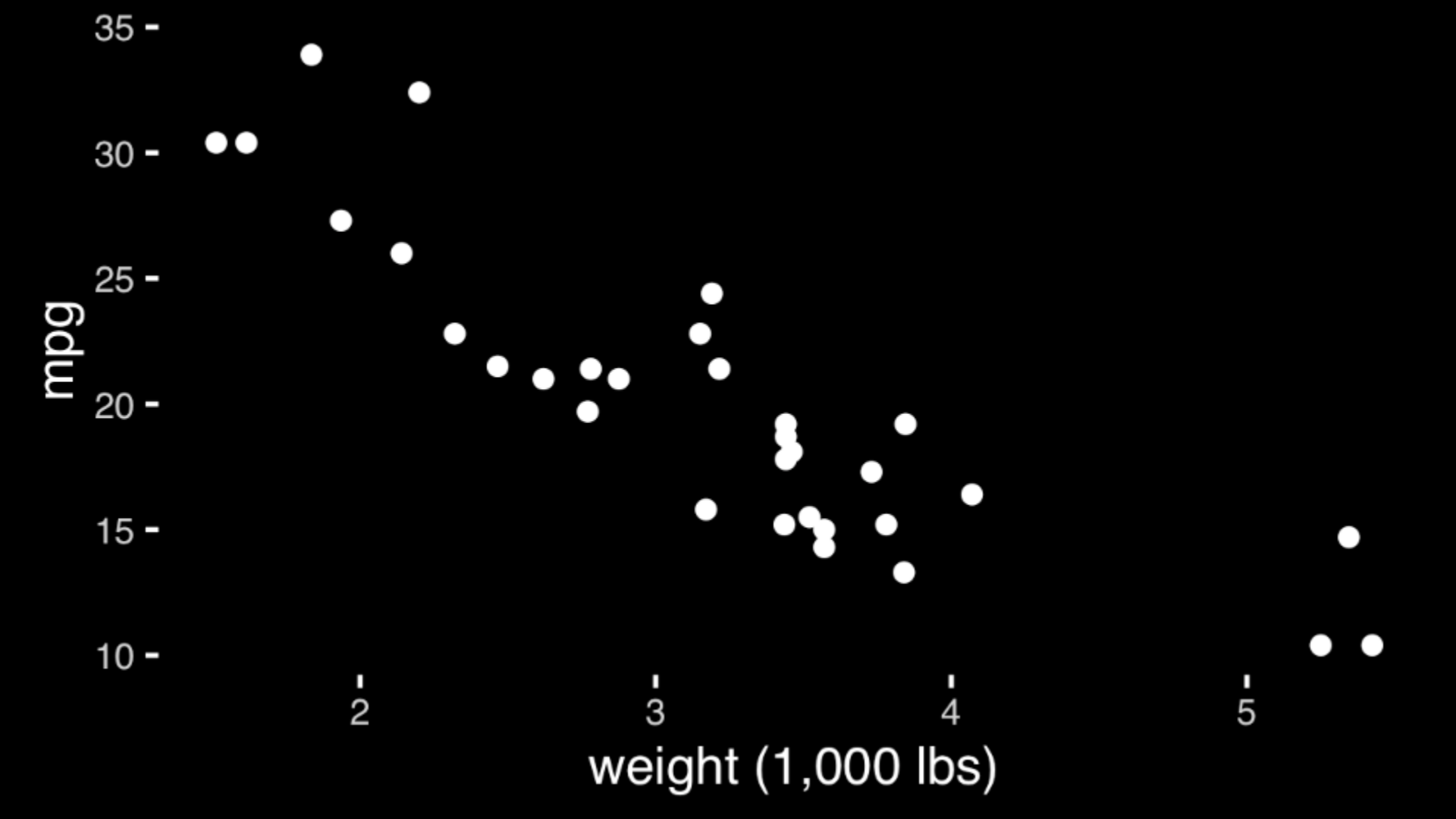
CONSTITUENCY-WISE EFFECT OF THE NOTA

The chart shows the number of votes that the NOTA votes polled in each constituency in descending order of magnitude. The points above the curve indicate the constituencies where the victory margins are more than the NOTA votes polled, while the points below the curve, vice-versa. The length of the lines indicate the quantum of the difference. Votes along the Y-axis are shown on a logarithmic scale to allow for comparison. Hover mouse cursor over the chart to explore constituency details.



Observation: Good plots leverage the law of continuity to assist with assembly.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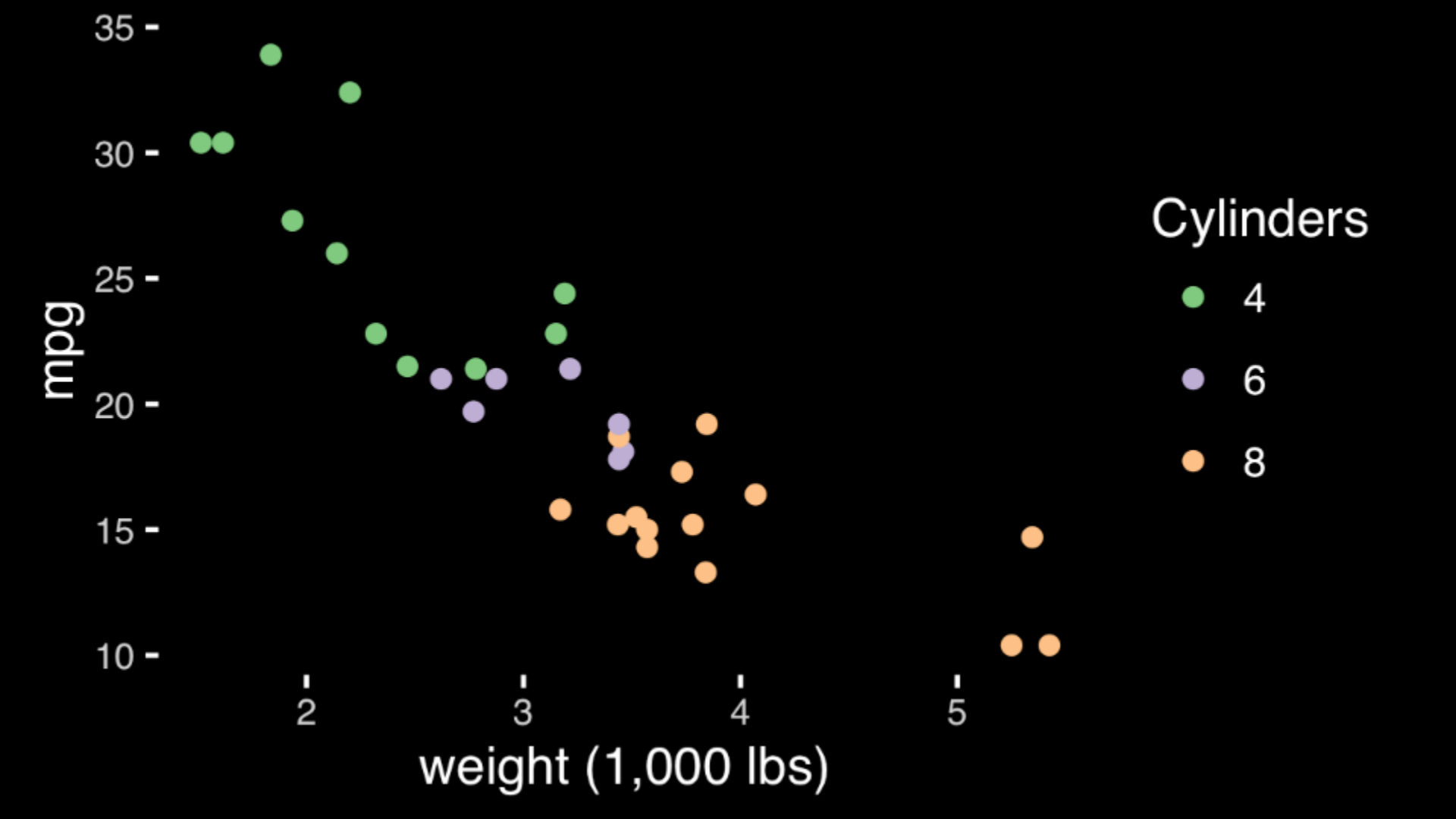
weight (1,000 lbs)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weight (1,000 lbs)
Cylinders
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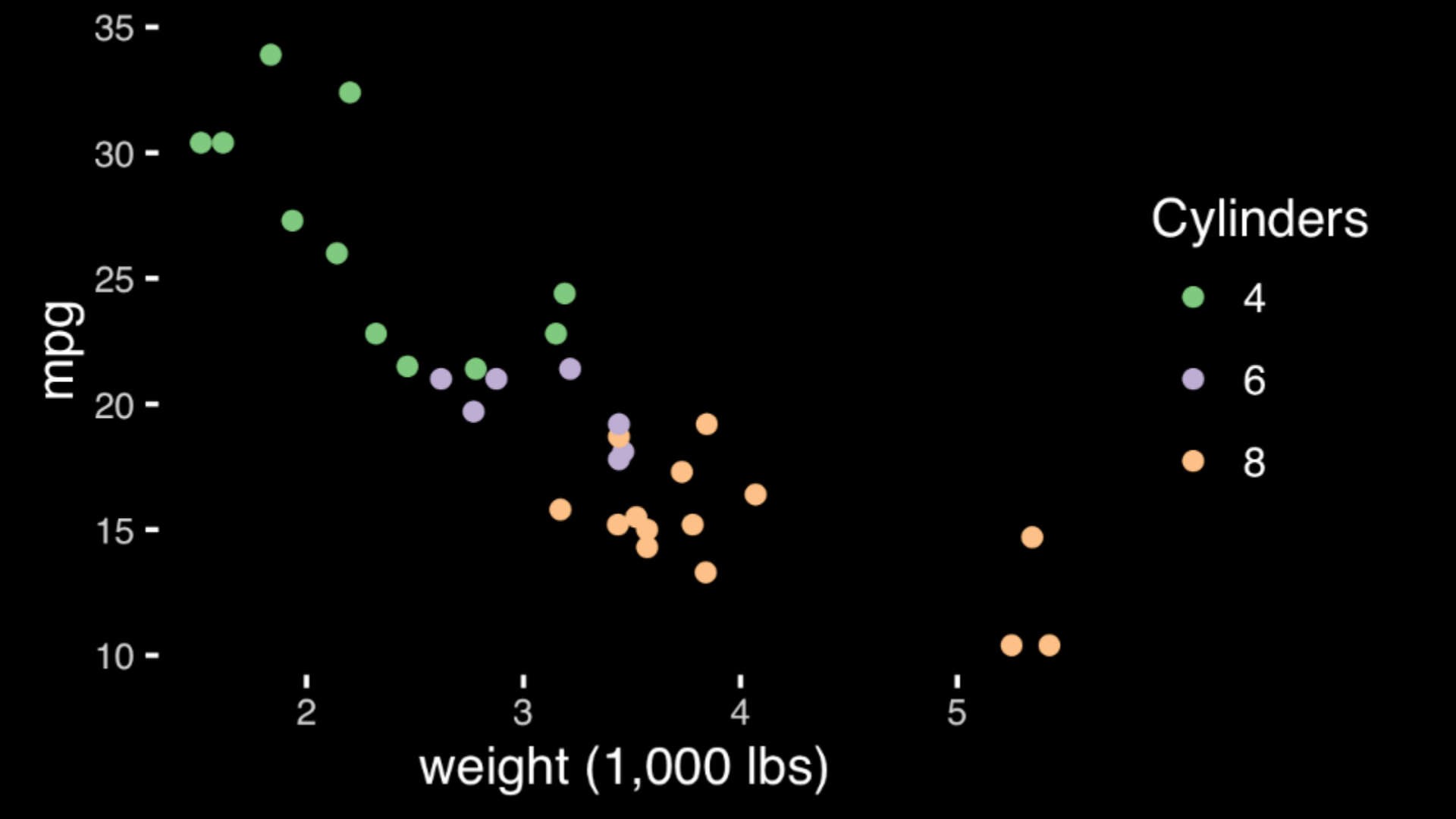
8

Law of Similarity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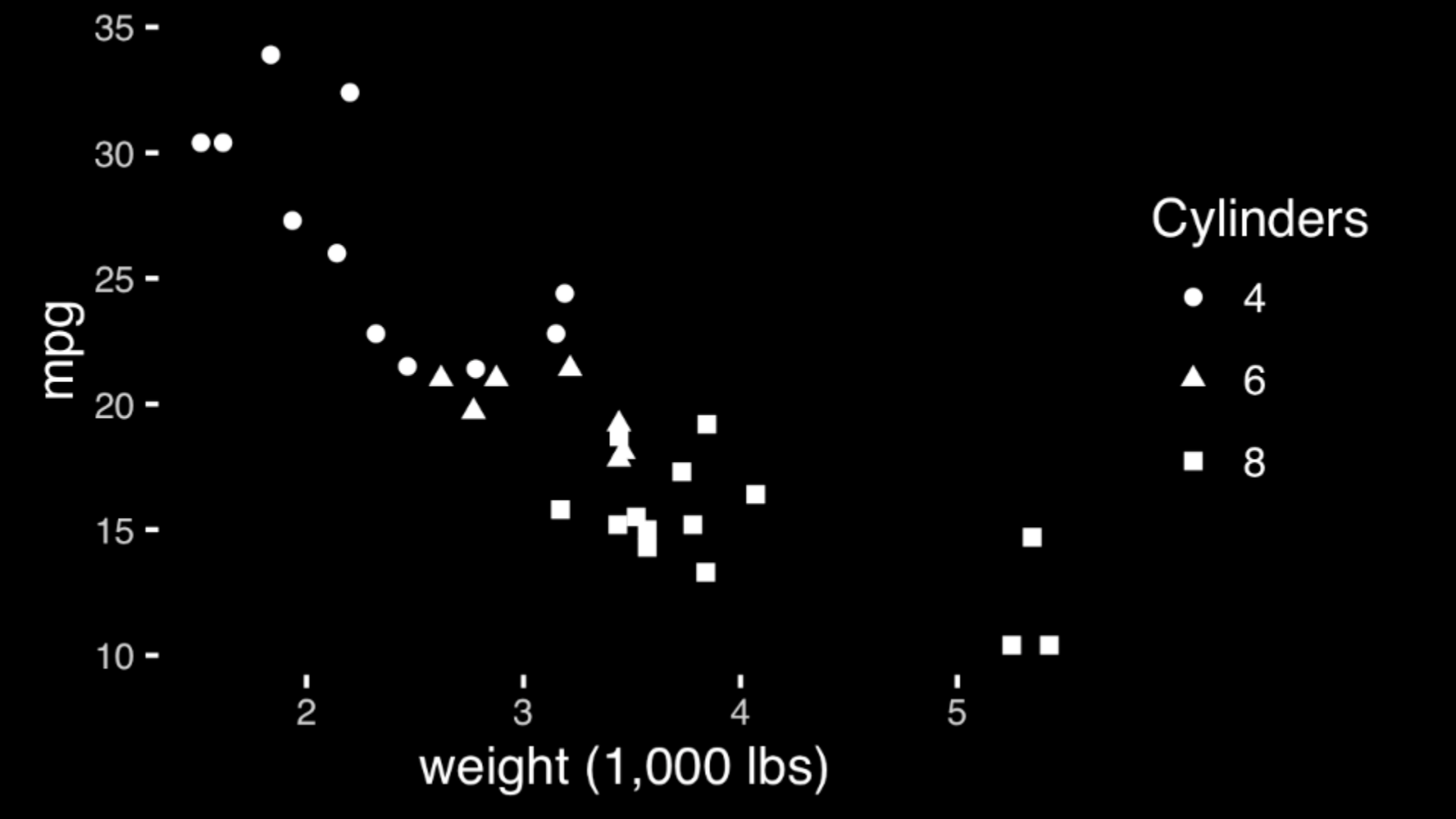
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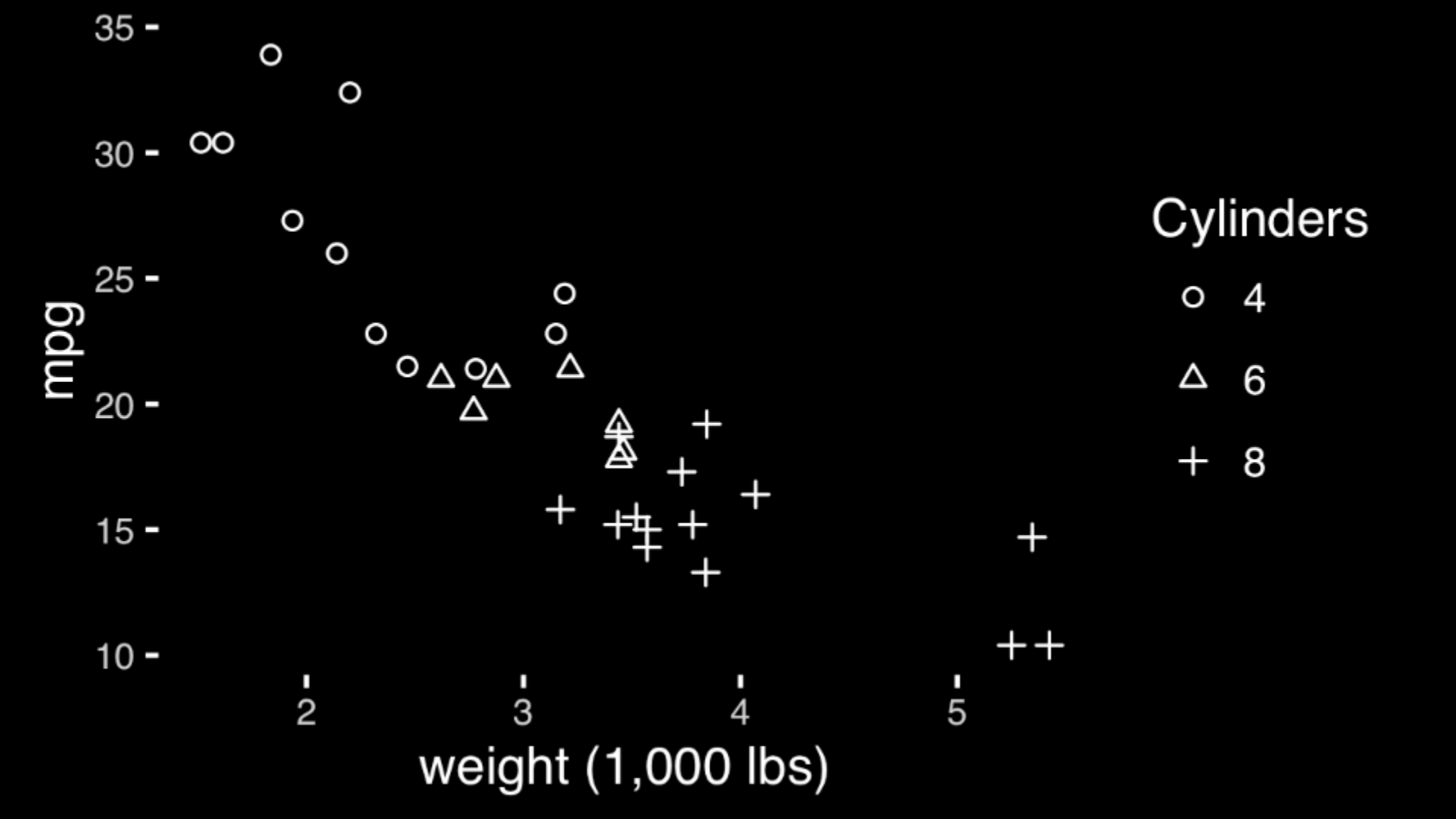
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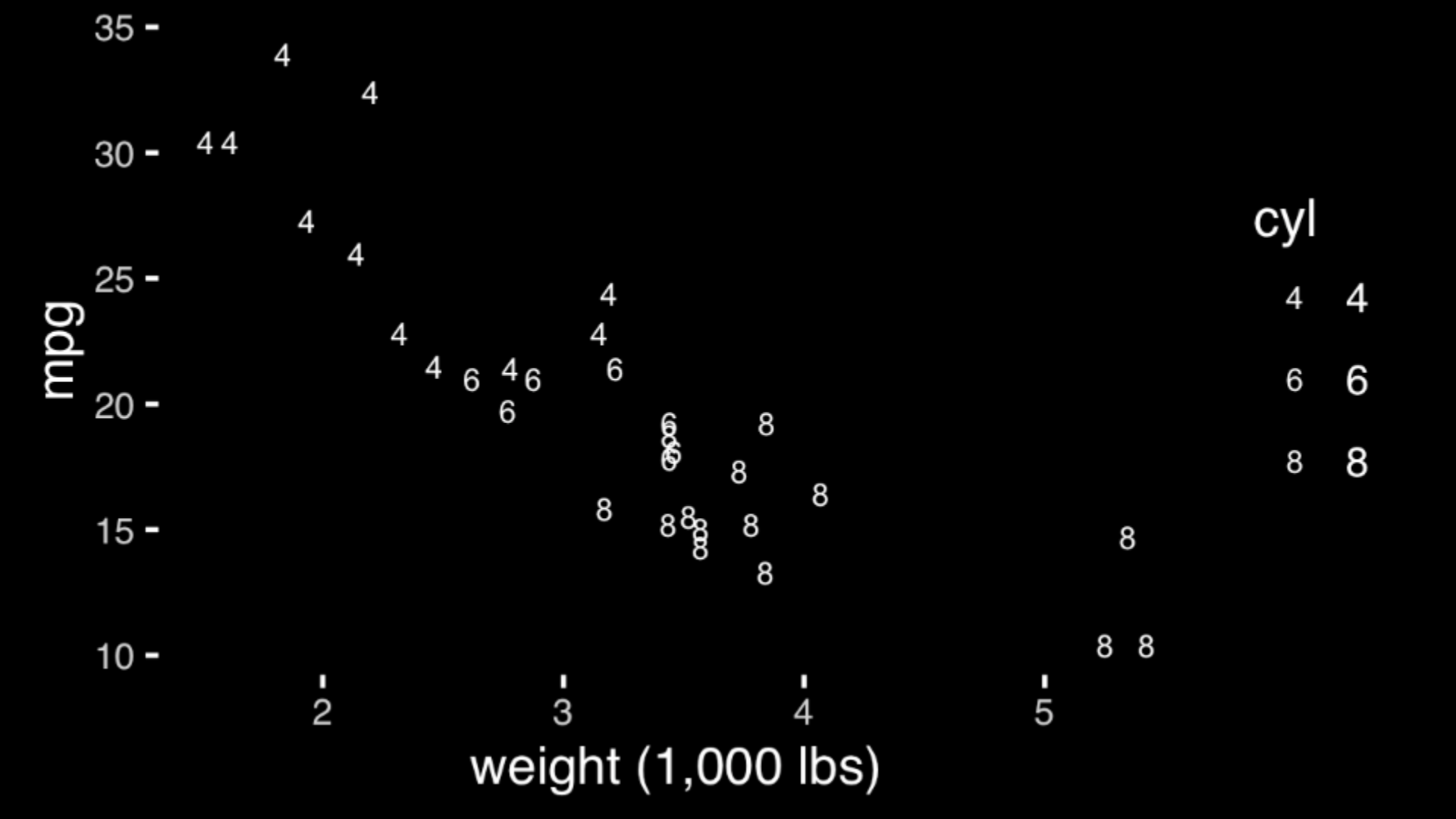
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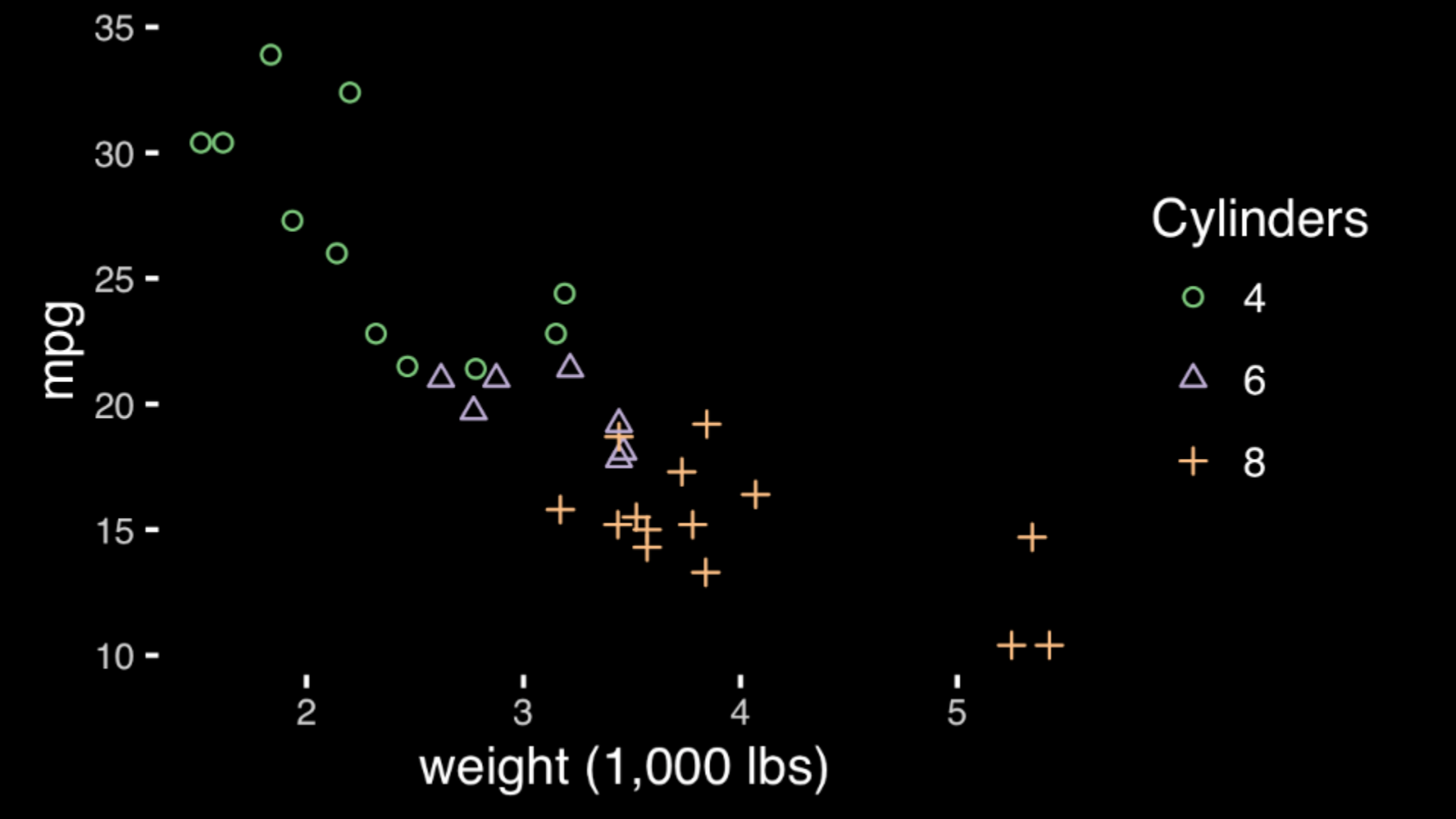
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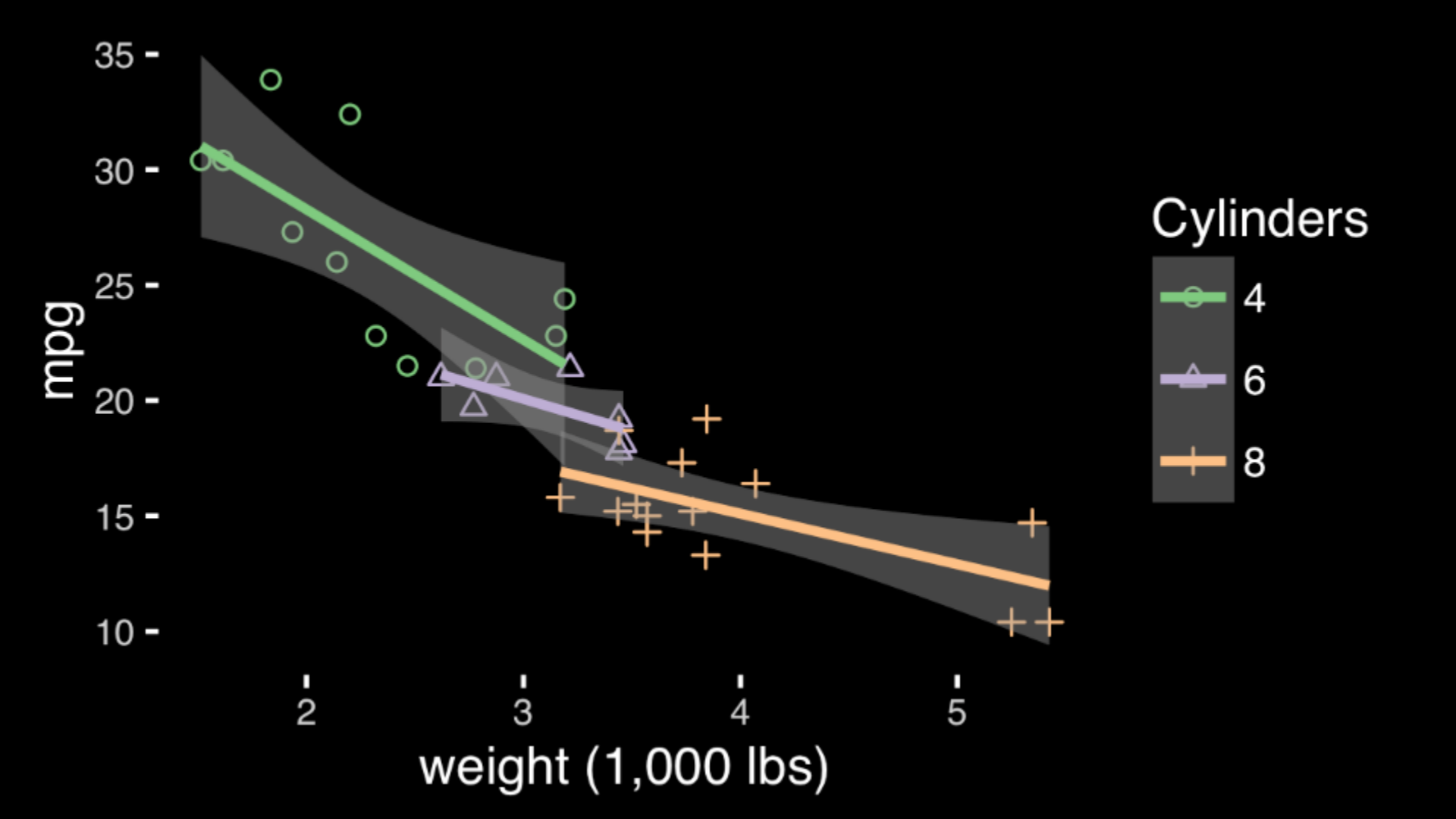
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weight (1,000 lbs)
Cylinders
4
6
8

Cleveland’s three visual operations of pattern perception:

1. Detection
2. Assembly
3. Estimation

3. Estimation

Three levels of estimation

a. discrimination X=Y X!=Y
b. ranking X>Y X<Y
c. ratioing X / Y = ?

At the heart of quantitative reasoning is a single question: Compared to what?

- Tufte, Envisioning Information

Three levels of estimation

a. discrimination X=Y X!=Y
b. ranking X>Y X<Y
c. ratioing X / Y = ?

Graphical Perception and Graphical Methods for Analyzing Scientific Data

William S. Cleveland and Robert McGill

Graphs provide powerful tools both for analyzing scientific data and for communicating quantitative information. The computer graphics revolution, which began in the 1960's and has intensified during the past several years, stimulated the invention of graphical methods for analyzing and presenting scientific data. ... mation from graphs; theory and experimental data are then used to order the tasks on the basis of accuracy. The ordering has an important application: data should be encoded so that the visual decoding involves tasks as high in the ordering as possible, that is, tasks per-

Summary. Graphical perception is the visual decoding of the quantitative and qualitative information encoded on graphs. Recent investigations have uncovered basic principles of human graphical perception that have important implications for the display of data. The computer graphics revolution has stimulated the invention of many graphical methods for analyzing and presenting scientific data, such as box plots, two-tiered error bars, scatterplot smoothing, dot charts, and graphing on a log base 2 scale.

al field that comes without apparent mental effort. We also perform cognitive tasks such as reading scale information, but much of the power of graphs—and what distinguishes them from tables—comes from the ability of our preattentive visual system to detect geometric patterns and assess magnitudes. We have examined preattentive processes rather than cognition.

We have studied the elementary graphical-perception tasks theoretically, borrowing ideas from the more general field of visual perception (*7, 8*), and experimentally by having subjects judge graphical elements (*1, 5*). The next two sections illustrate the methodology with a few examples.

Study of Graphical Perception: Theory

Figure 2 provides an illustration of theoretical reasoning that borrows some ideas from the field of computational vision (*8*). Suppose that the goal is to judge the ratio, r, of the slope of line segment BC to the slope of line segment AB in each of the three panels. Our visual system tells us that r is greater than 1 in each panel, which is correct. Our visual system also tells us that r is

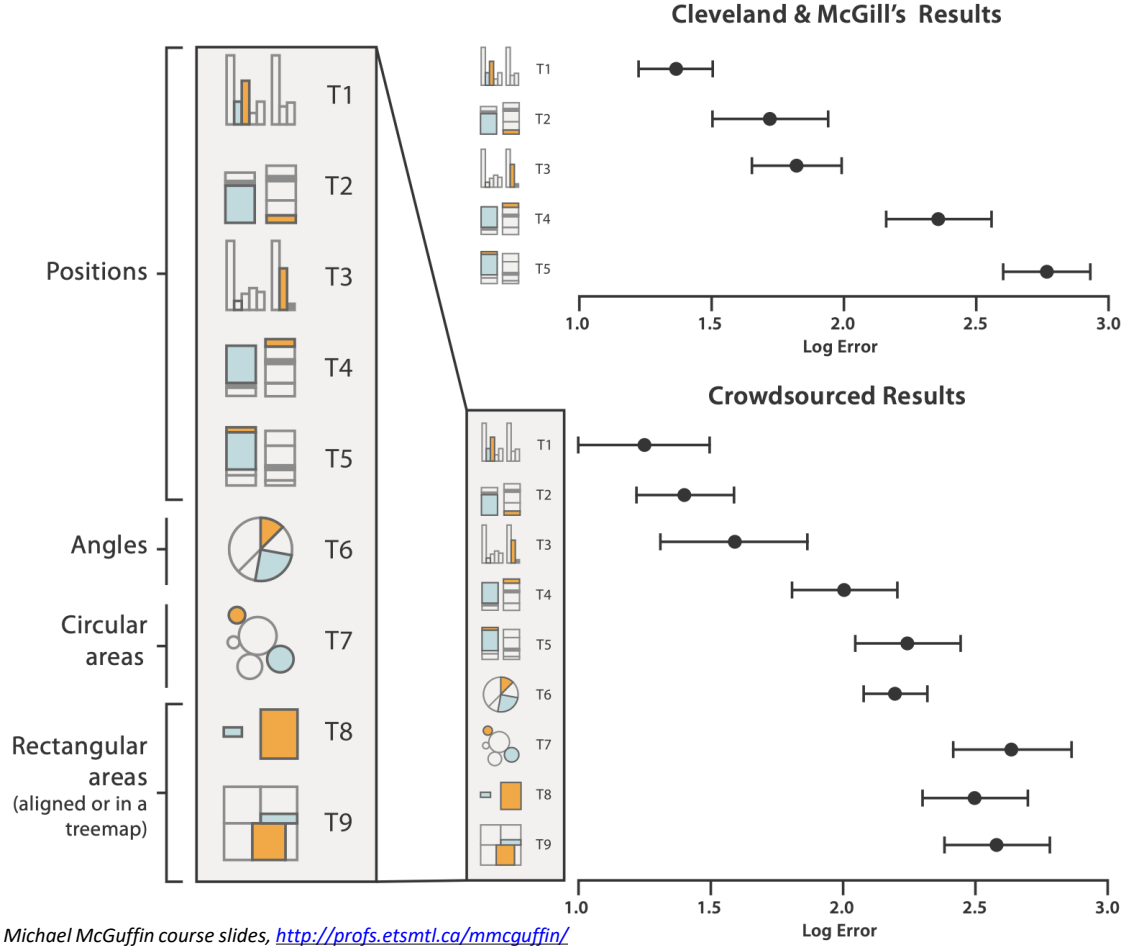
Table 1. Ordering elementary tasks by accuracy, according to theoretical arguments and experimental results. Graphs should exploit tasks as high in the ordering as possible. The tasks are ordered from most accurate to least.

Rank	Aspect judged
1	Position along a common scale
2	Position on identical but nonaligned scales
3	Length
4	Angle
	Slope (with θ not too close to 0, $\pi/2$, or π radians)
5	Area
6	Volume
	Density
	Color saturation
7	Color hue

The most important measurement should exploit the highest ranked encoding possible.

- Position along a common scale
- Position on identical but nonaligned scales
- Length
- Angle or Slope
- Area
- Volume or Density or Color saturation
- Color hue

Accuracy: Vis experiments



after Michael McGuffin course slides, http://profs.etsmtl.ca/mmcguffin/

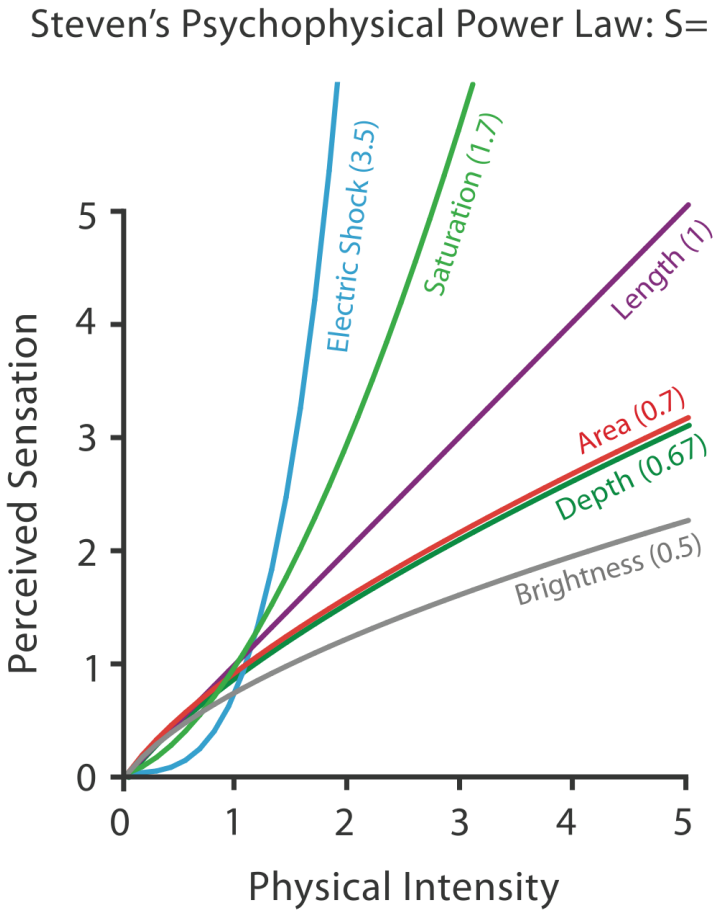
[Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Heer and Bostock. Proc ACM Conf. Human Factors in Computing Systems (CHI) 2010, p. 203–212.]

Channel effectiveness

- accuracy: how precisely can we tell the difference between encoded items?
- discriminability: how many unique steps can we perceive?
- separability: is our ability to use this channel affected by another one?
- popout: can things jump out using this channel?
- Semantics: can data attributes be meaningfully mapped to channels?

Accuracy: Fundamental theory

- length is accurate: linear
- others magnified or compressed
  - exponent characterizes



S = sensation

I = intensity

Factors affecting accuracy

- alignment
- distractors
- distance
- common scale / alignment

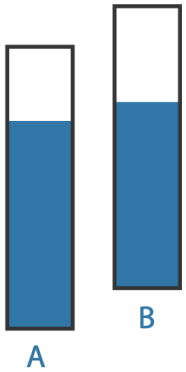
Relative vs. absolute judgements

- perceptual system mostly operates with relative judgements, not absolute

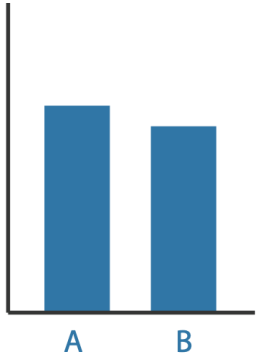
Relative vs. absolute judgements

- perceptual system mostly operates with relative judgements, not absolute
  - that's why accuracy increases with common frame/scale and alignment

length



position along unaligned common scale



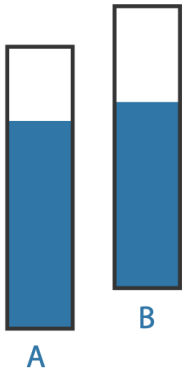
position along aligned scale

after [Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. Cleveland and McGill. Journ. American Statistical Association 79:387 (1984), 531–554.]

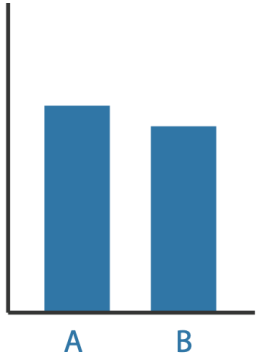
Relative vs. absolute judgements

- perceptual system mostly operates with relative judgements, not absolute
  - that's why accuracy increases with common frame/scale and alignment
  - Weber's Law: ratio of increment to background is constant

length



position along unaligned common scale



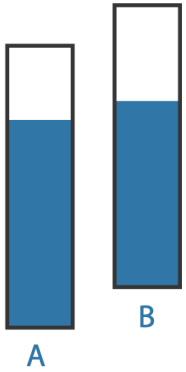
position along aligned scale

after [Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. Cleveland and McGill. Journ. American Statistical Association 79:387 (1984), 531–554.]

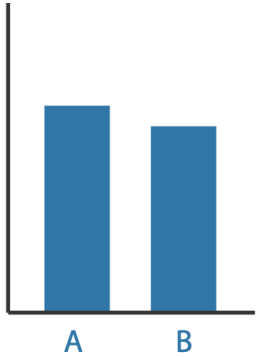
Relative vs. absolute judgements

- perceptual system mostly operates with relative judgements, not absolute
  - that's why accuracy increases with common frame/scale and alignment
  - Weber's Law: ratio of increment to background is constant
    - filled rectangles differ in length by 1:9, difficult judgement
    - white rectangles differ in length by 1:2, easy judgement

length



position along unaligned common scale

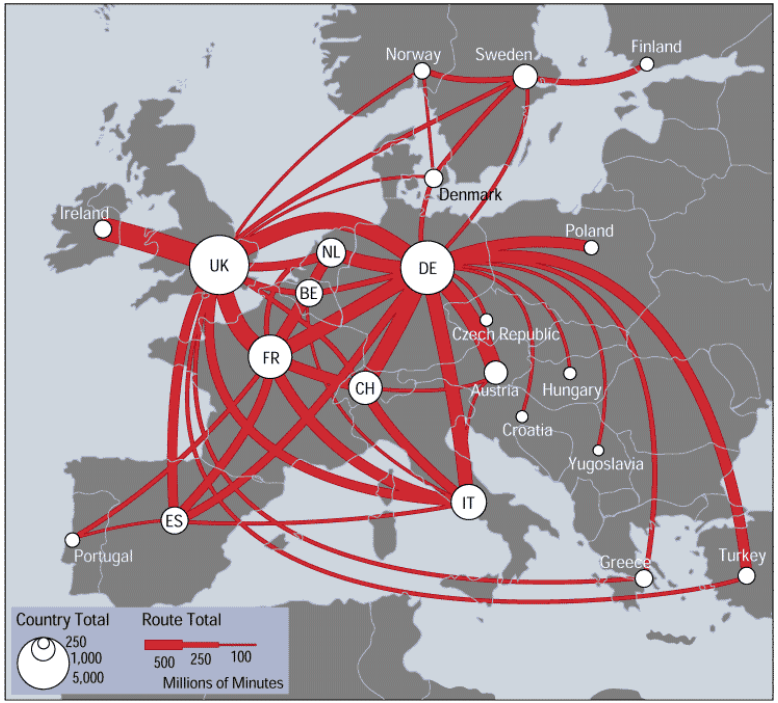


position along aligned scale

after [Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. Cleveland and McGill. Journ. American Statistical Association 79:387 (1984), 531–554.]

Discriminability: How many usable steps?

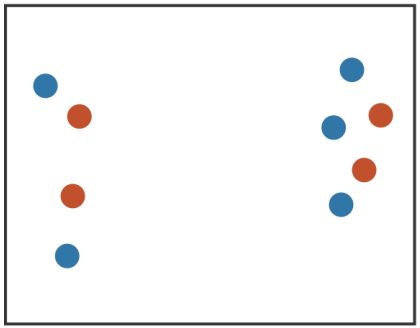
- must be sufficient for number of attribute levels to show
  - linewidth: few bins



[mappa.mundi.net/maps/maps 014/telegeography.html]

Separability vs. Integrality

Position
+ Hue (Color)

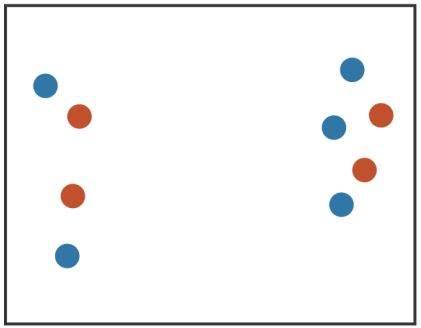


Fully separable

2 groups each

Separability vs. Integrality

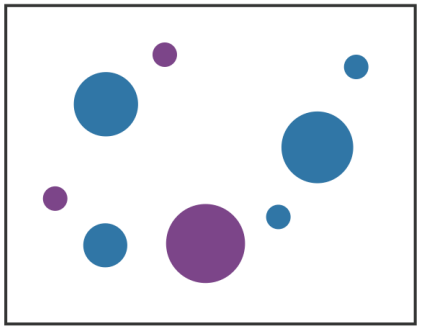
Position
+ Hue (Color)



Fully separable

2 groups each

Size
+ Hue (Color)

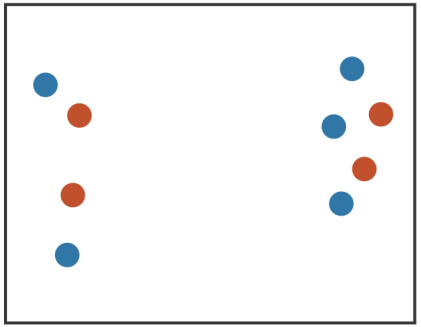


Some interference

2 groups each

Separability vs. Integrality

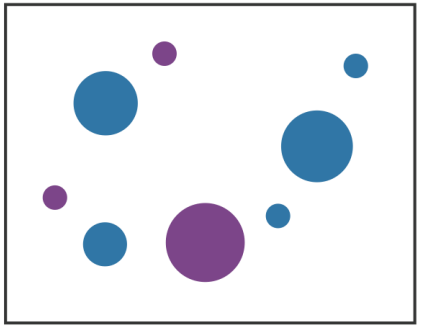
Position
+ Hue (Color)



Fully separable

2 groups each

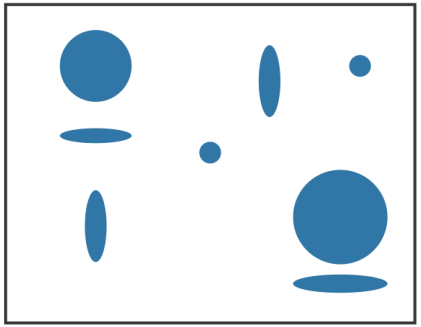
Size
+ Hue (Color)



Some interference

2 groups each

Width
+ Height

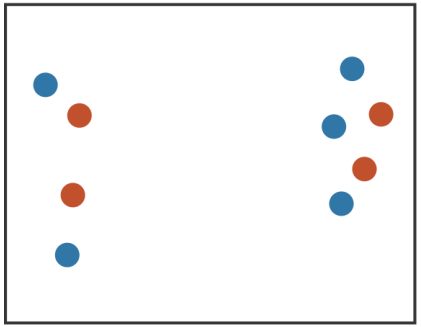


Some/significant interference

3 groups total: integral area

Separability vs. Integrality

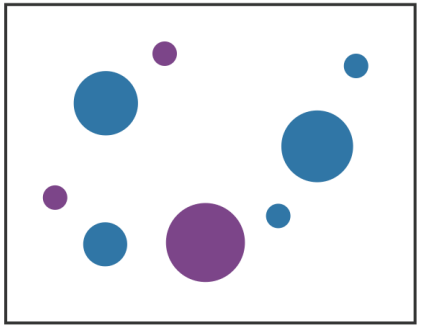
Position
+ Hue (Color)



Fully separable

2 groups each

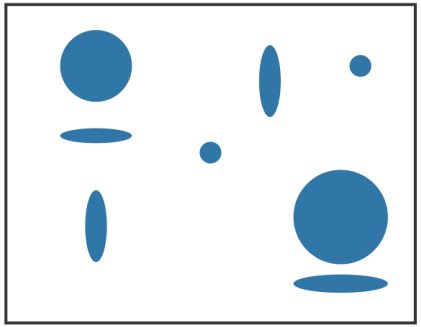
Size
+ Hue (Color)



Some interference

2 groups each

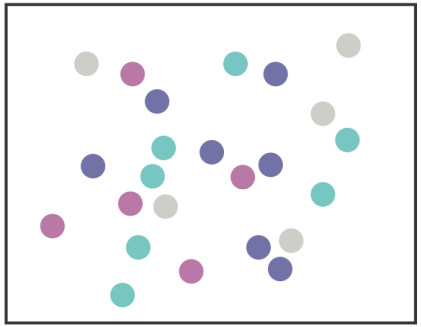
Width
+ Height



Some/significant interference

3 groups total: integral area

Red
+ Green



Major interference

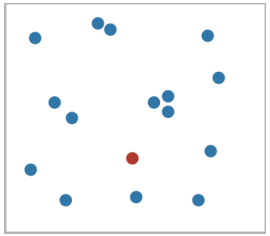
4 groups total: integral hue

Popout

- find the red dot
  - how long does it take?

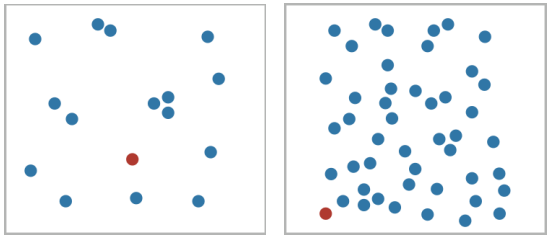
Popout

- find the red dot
  - how long does it take?



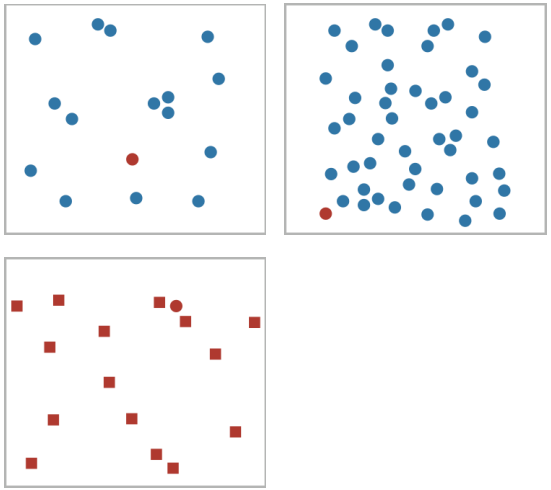
Popout

- find the red dot
  - how long does it take?



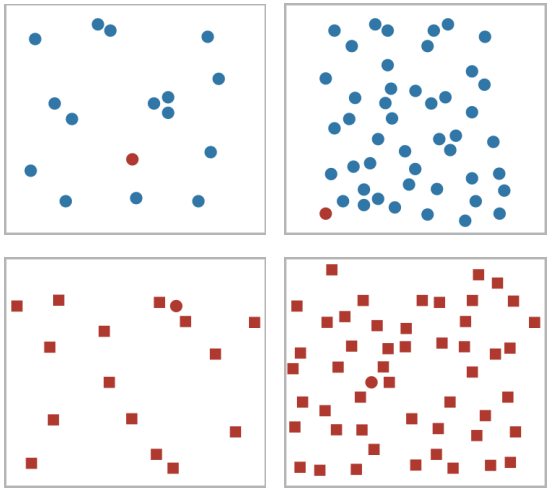
Popout

- find the red dot
  - how long does it take?



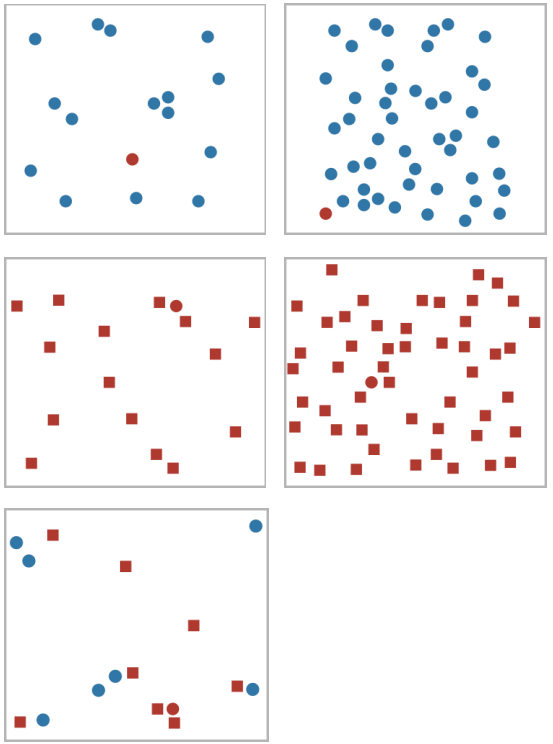
Popout

- find the red dot
  - how long does it take?



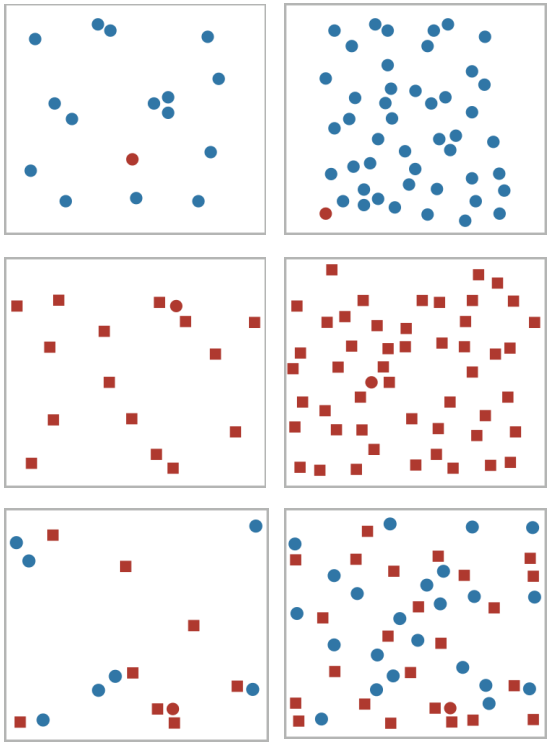
Popout

- find the red dot
  - how long does it take?



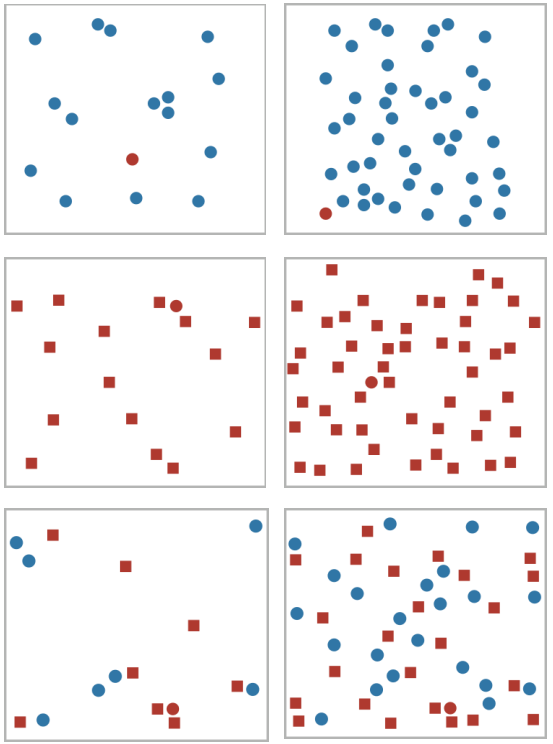
Popout

- find the red dot
  - how long does it take?

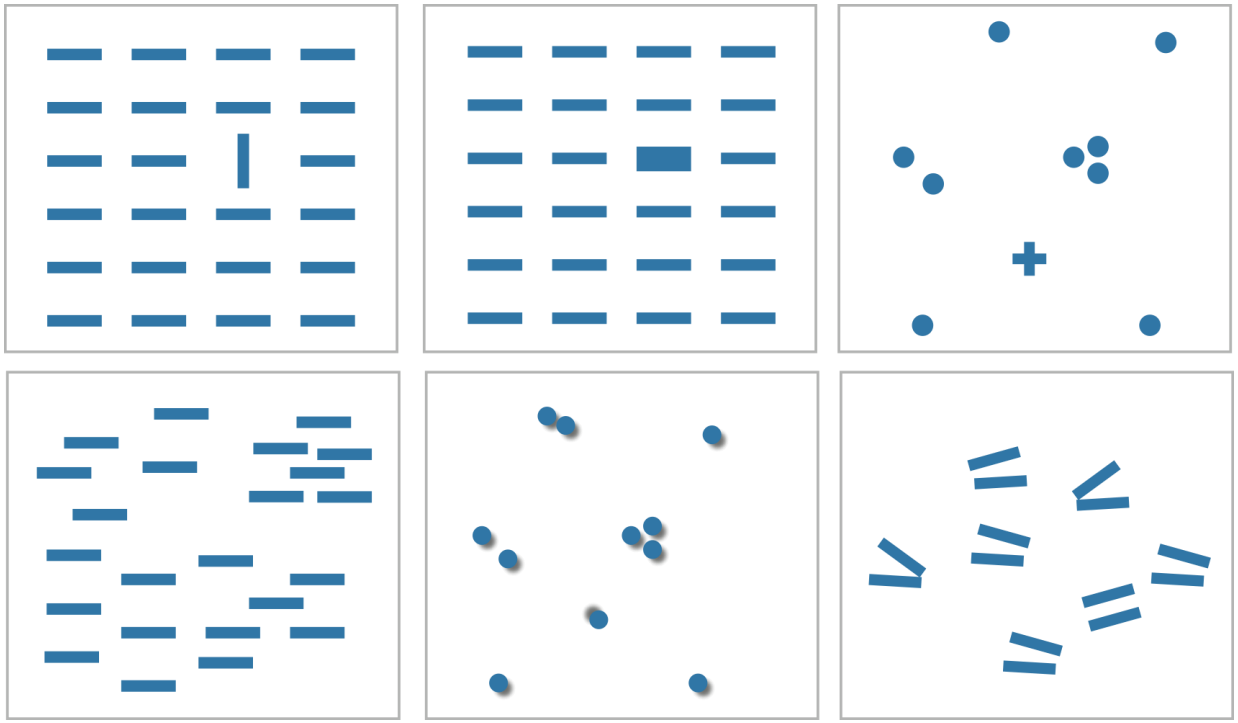


Popout

- find the red dot
  - how long does it take?
- parallel processing on many individual channels
  - speed independent of distractor count
  - speed depends on channel and amount of difference from distractors
- serial search for (almost all) combinations
  - speed depends on number of distractors

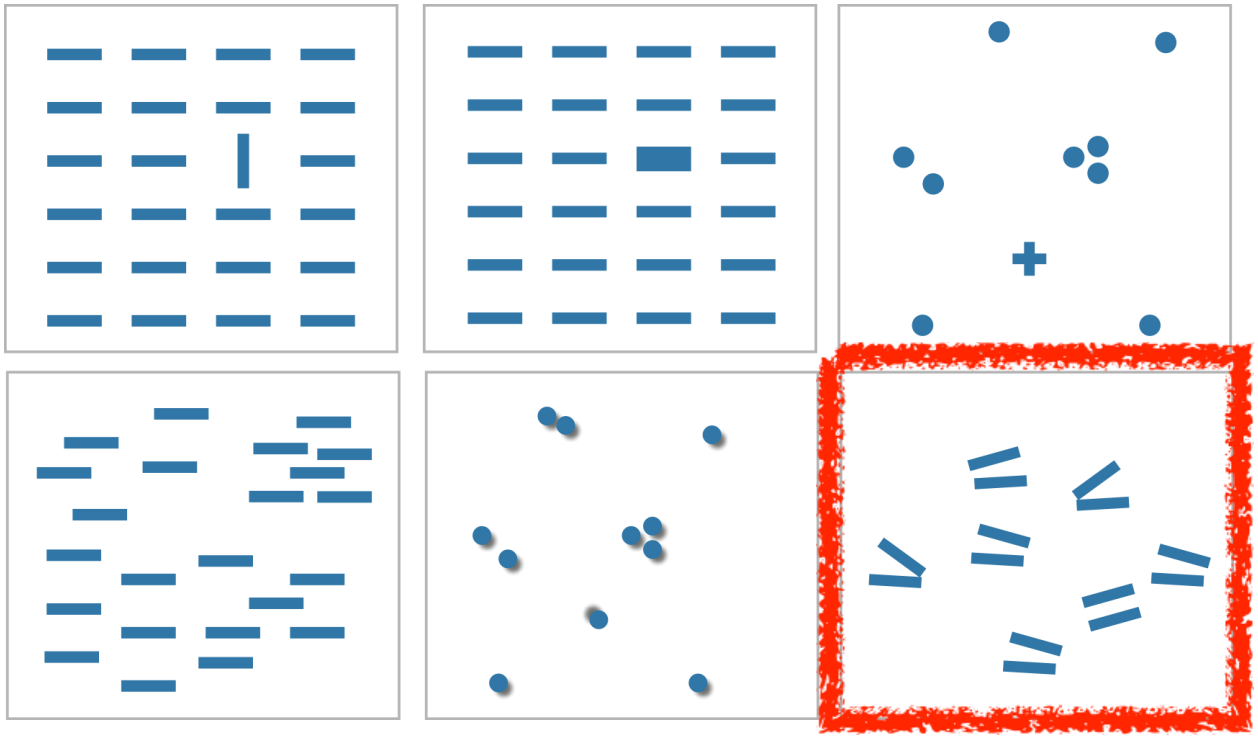


Popout



- many channels
  - tilt, size, shape, proximity, shadow direction, ...

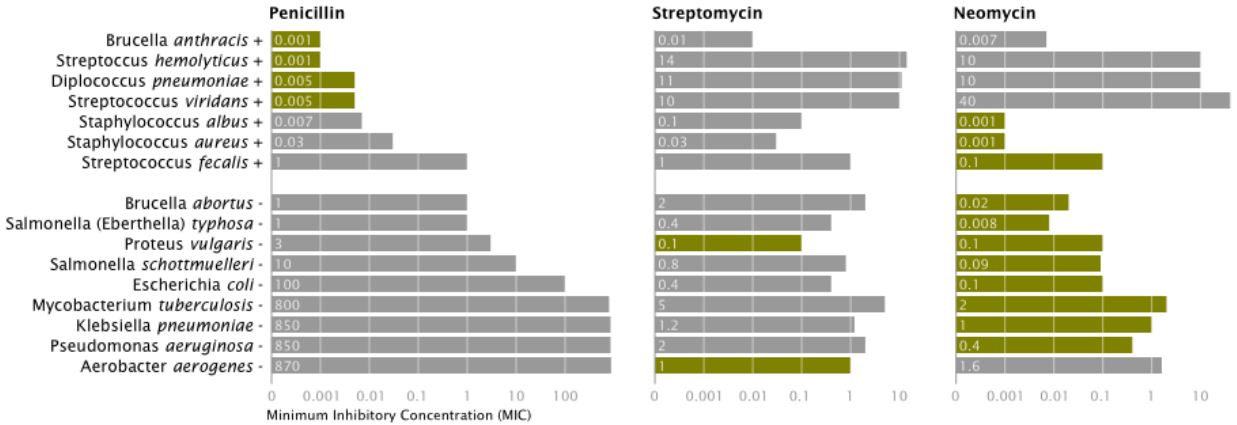
Popout



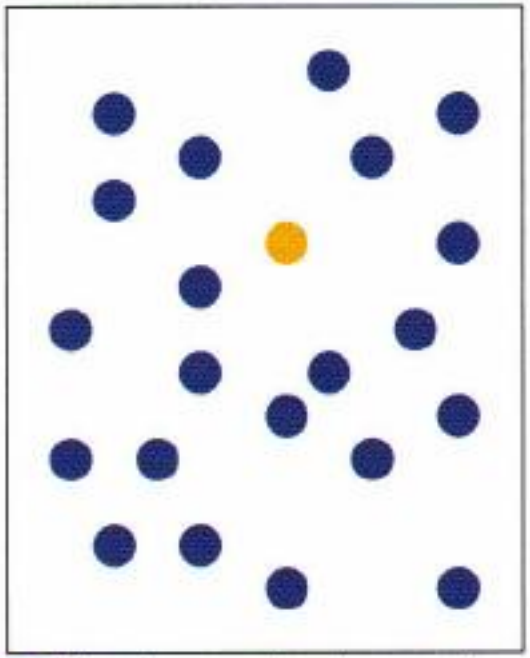
- many channels
  - –tilt, size, shape, proximity, shadow direction, ...
- but not all!
  - – parallel line pairs do not pop out from tilted pairs

Popout

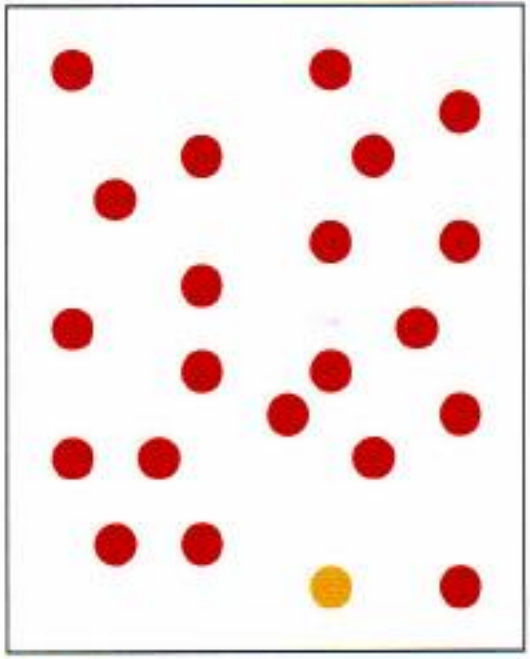
- We can easily see objects that are different in colour and shape, or that are in motion
- Use colour and shape sparingly to make the salient information pop out



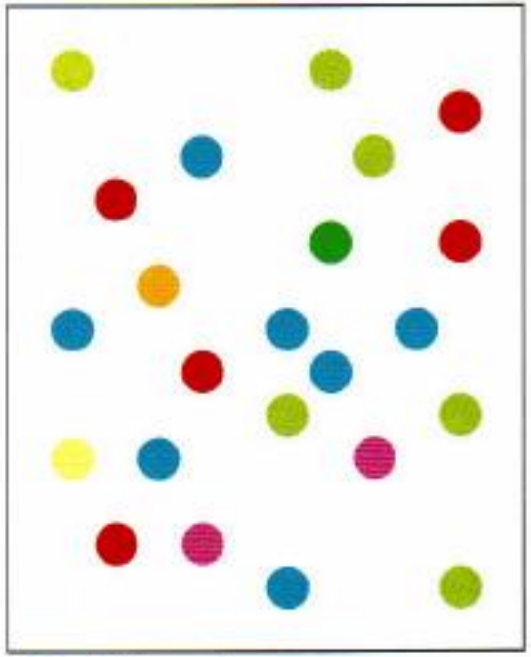
Mike Bostock, 2009



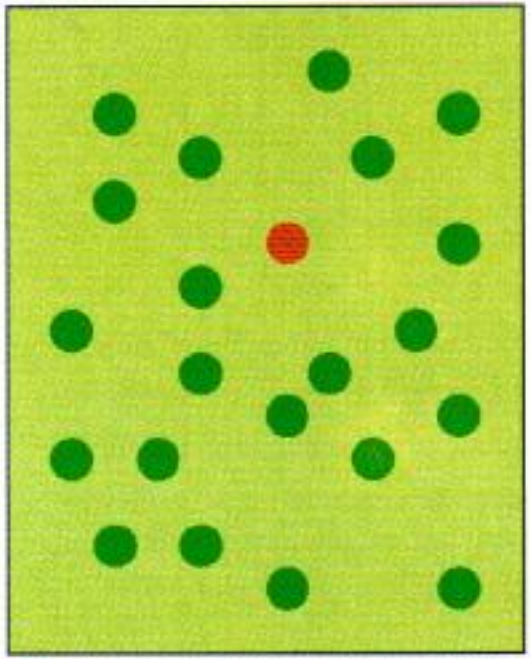
The larger the chromatic difference between the target symbol and the other symbols, the easier the search.



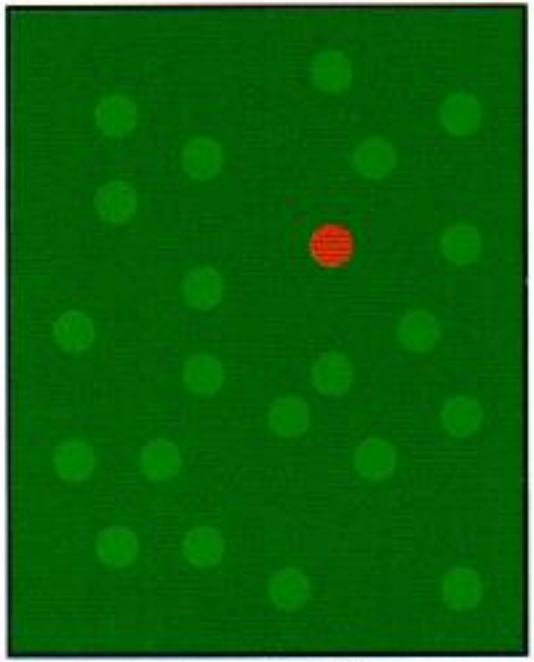
When there is only a small color difference from non-target symbols, the search is difficult.



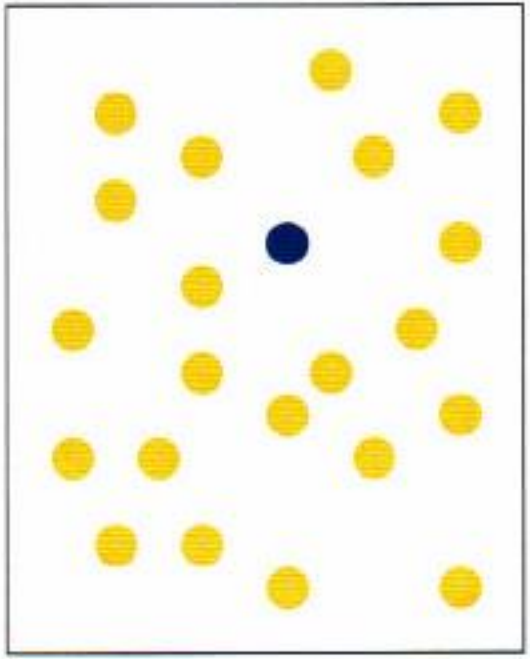
When there are many non-target symbol colors, the search is the most difficult.



If non-target symbols are similar to the background, they are easy to exclude from the visual search.

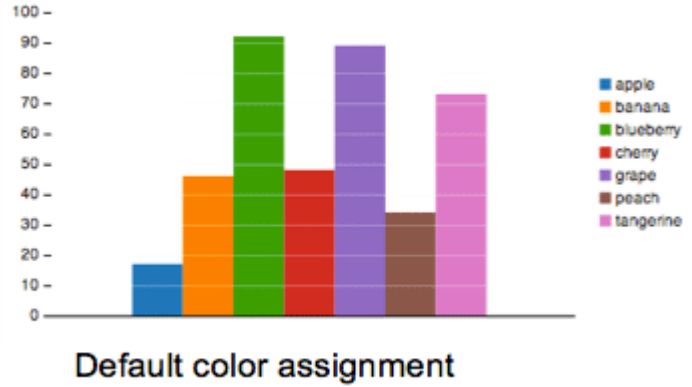


A luminance difference plus a chromatic difference from other symbols and the background leads to the easiest search.

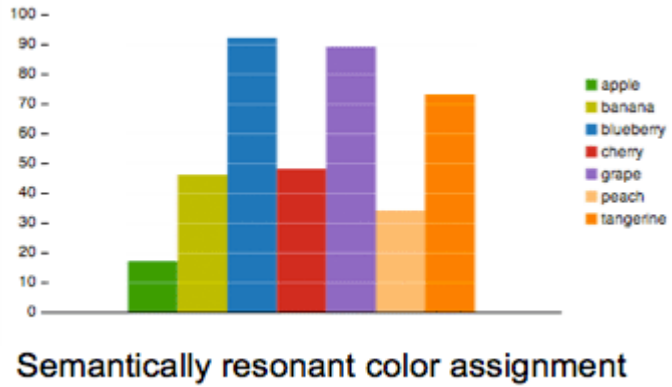


A dark target on a light background with light non-target symbols can be as effective as the reverse.

Semantically Resonant Colour Assignments



Default color assignment



Semantically resonant color assignment

Semantically-resonant colours improve speed on chart reading tasks compared to a standard palette

Stroop Effect

Stroop Effect: interference in the reaction time of a task

Green Red Blue Purple Blue Purple

Stroop Effect

Stroop Effect: interference in the reaction time of a task

Green Red Blue Purple Blue Purple

Blue Purple Red Green Purple Green

Stroop Effect

- brain's ability to recognize the colour of the word since the brain reads words faster than it recognizes colours
- colour recognition as opposed to reading a word, requires more attention
- recognizing colours is not an “automatic process" there is hesitancy to respond; whereas, the brain automatically understands the meaning of words as a result of habitual reading

Encoding semantics

Graphical Code		Semantics
Small shapes defined by closed contour, texture, color, shaded solid.		Object, idea, entity, node.
Spatially ordered graphical objects.		Related information or a sequence. In a sequence the left-to-right ordering convention borrows from the western convention for written language.
Graphical objects in proximity.		Similar concepts, related information.
Graphical objects having the same shape, color, or texture.		Similar concepts, related information.
Size of graphical object Height of graphical object.		Magnitude, quantity, importance.
Shapes connected by contour.		Related entities, path between entities.
Thickness of connecting contour.		Strength of relationship.
Color and texture of connecting contour.		Type of relationship.
Shapes enclosed by a contour, or a common texture, or a common color.		Contained entities. Related entities.
Nested regions, partitioned regions.		Hierarchical concepts.
Attached shapes.		Parts of a conceptual structure.

Visual Thinking for Design, Colin Ware

When to use which channel?

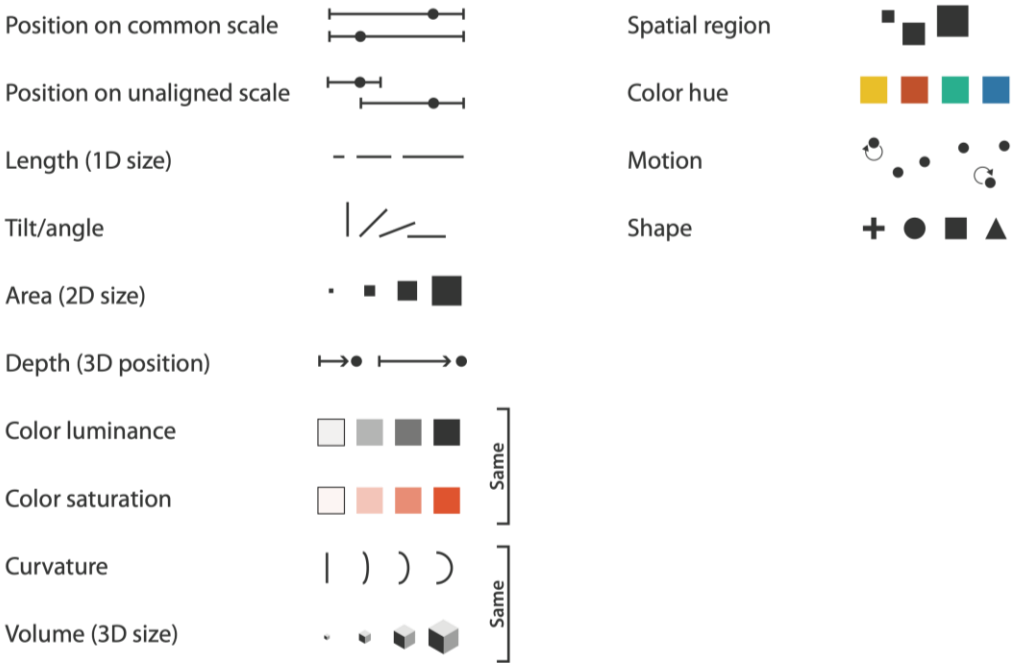
Expressiveness

match channel type to data type

Effectiveness

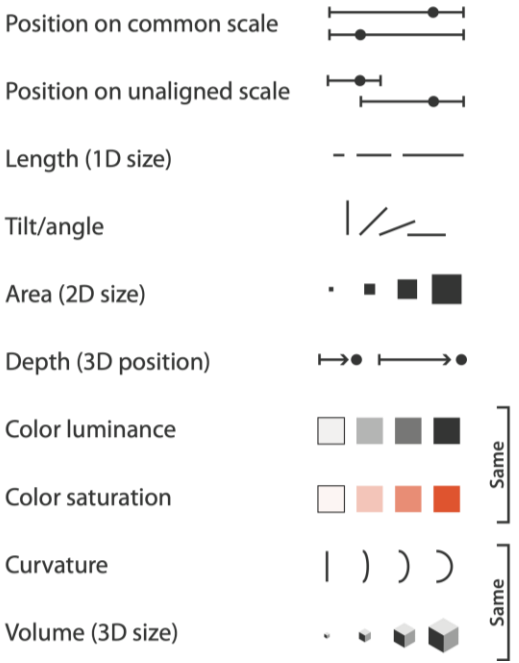
some channels are better than others

Channels: Rankings



Channels: Rankings

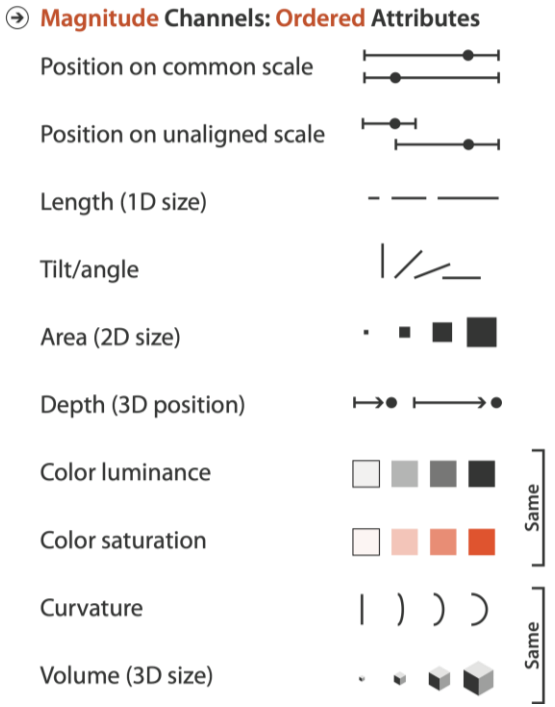
Magnitude Channels: Ordered Attributes

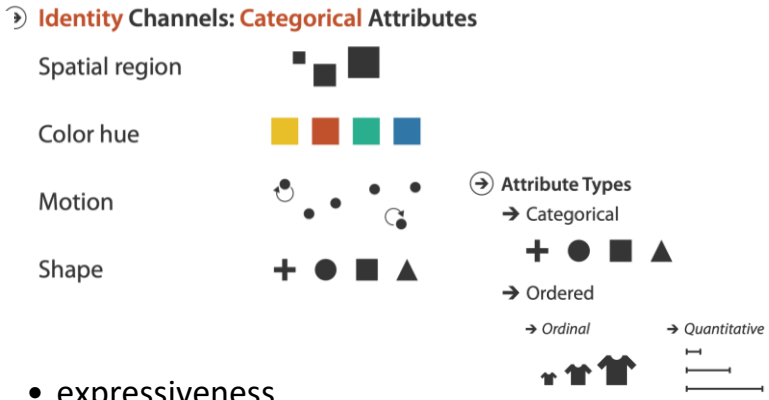


Identity Channels: Categorical Attributes

- expressiveness
  - match channel and data characteristics

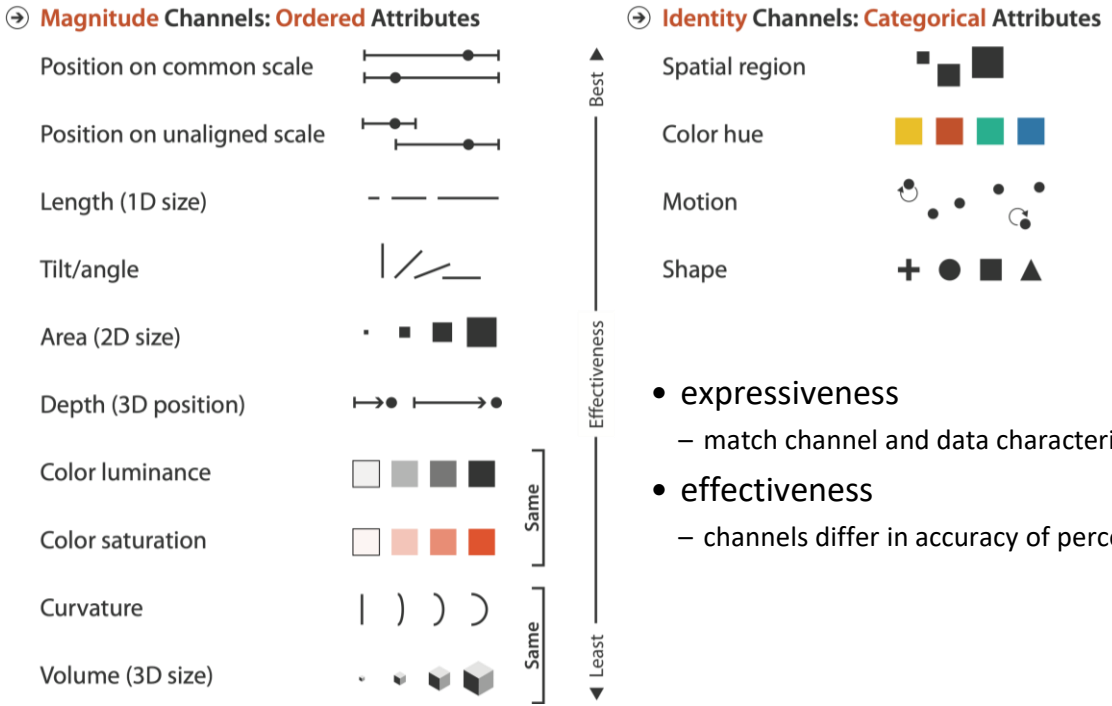
Channels: Rankings





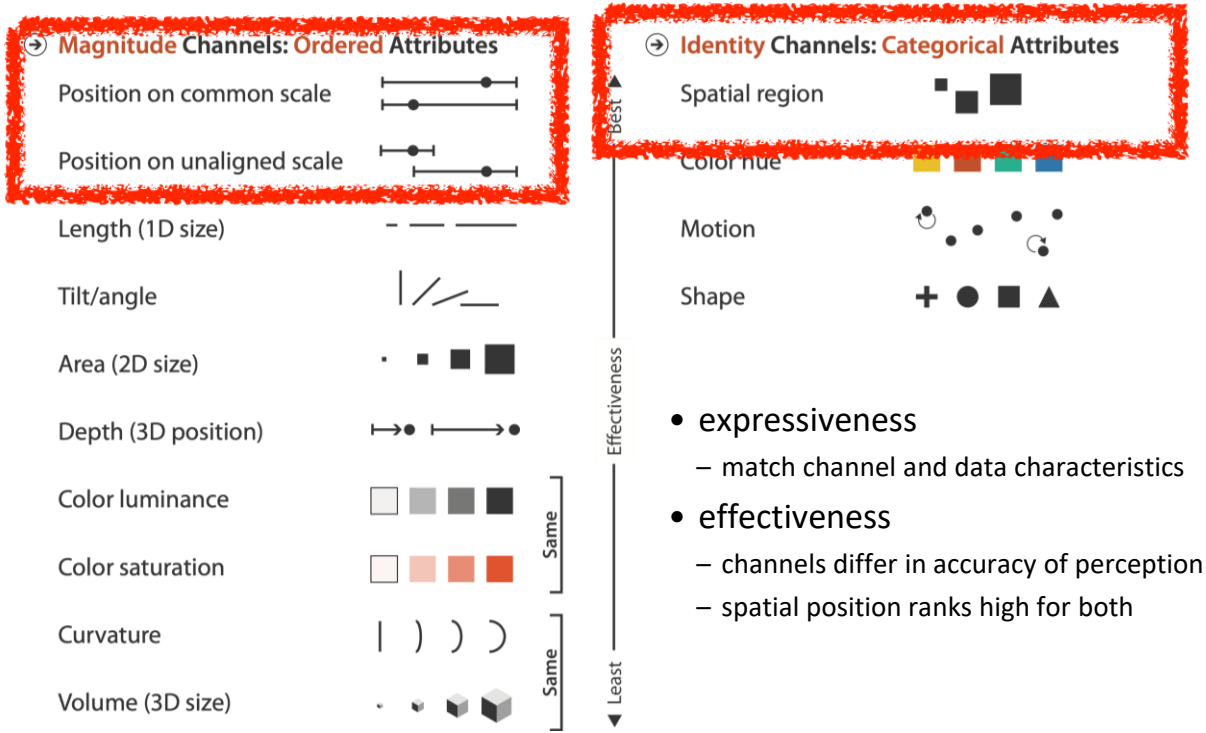
- expressiveness
  - match channel and data characteristics
    - magnitude for ordered
      - how much? which rank?
    - identity for categorical
      - what?

Channels: Rankings



- expressiveness
  - match channel and data characteristics
- effectiveness
  - channels differ in accuracy of perception

Channels: Rankings

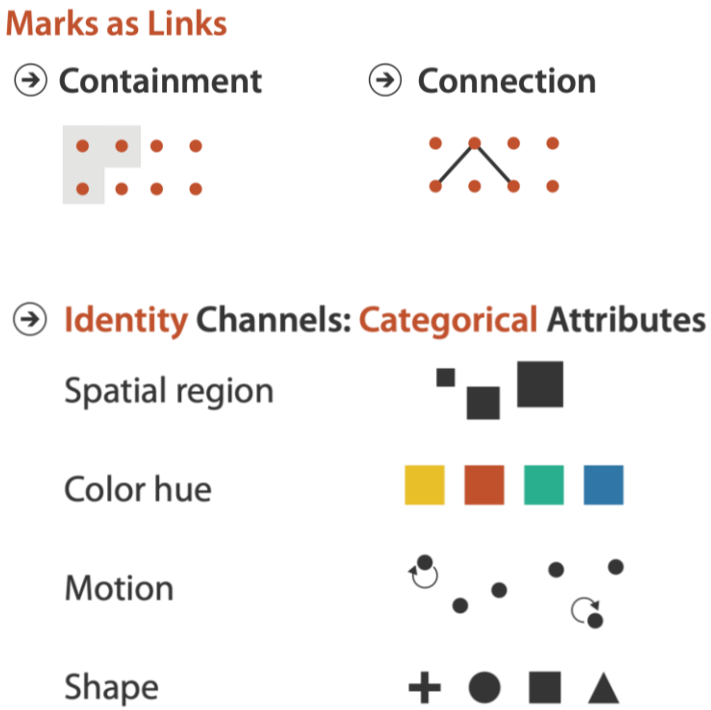


- expressiveness
  - match channel and data characteristics
- effectiveness
  - channels differ in accuracy of perception
  - spatial position ranks high for both

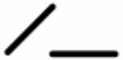
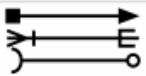
Grouping

- containment
- connection

- proximity
  - same spatial region
- similarity
  - same values as other categorical channels



Properties and Best Uses of Visual Encodings

Example	Encoding	Ordered	Useful values	Quantitative	Ordinal	Categorical	Relational
	position, placement	**yes**	**infinite**	Good	Good	Good	Good
1, 2, 3; A, B, C	text labels	**optional** (alphabetical or numbered)	**infinite**	Good	Good	Good	Good
	length	**yes**	**many**	Good	Good		
	size, area	**yes**	**many**	Good	Good		
	angle	**yes**	medium/few	Good	Good		
	pattern density	**yes**	few	Good	Good		
	weight, boldness	**yes**	few		Good		
	saturation, brightness	**yes**	few		Good		
	color	no	few (< 20)			Good	
	shape, icon	no	medium			Good	
	pattern texture	no	medium			Good	
	enclosure, connection	no	**infinite**			Good	Good
	line pattern	no	few				Good
	line endings	no	few				Good
	line weight	**yes**	few		Good		

Noah Iliinsky • ComplexDiagrams.com/properties • 2012-06

Questions?

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http://info-design-lab.github.io