Visualisation d'information (2)
Enjeux perceptifs

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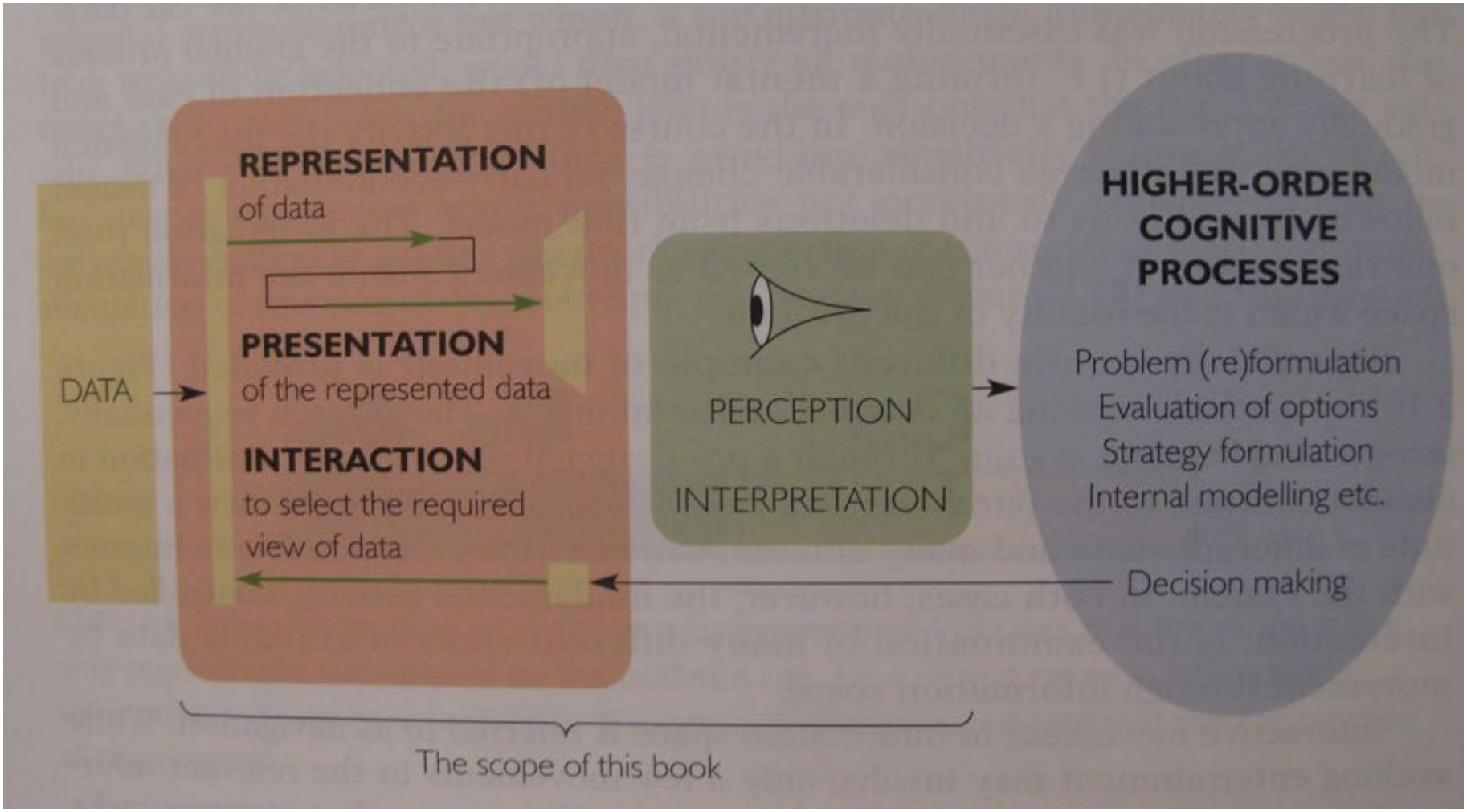
Déc. 2020

le cnam

Plan de l'exposé

1. Des données à la construction graphique
2. La vision pré-attentive
3. La couleur
4. La lisibilité
5. Choix des attributs graphiques

1. Des données à la construction graphique



[Spence] p.26 (cf cours #1)

Typologie des données

- (Q) quantitatives
    - cours de l'euro, température, date , altitude
    - op : égalité, classement, arithmétique

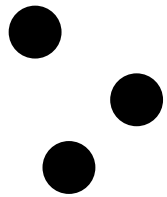
- (O) ordinales
    - ex: confort d'hôtels *,**,***,****
    - op: égalité, classement

- (N) nominales
    - ex: renault, peugeot, citroen, panhard
    - op: egalité

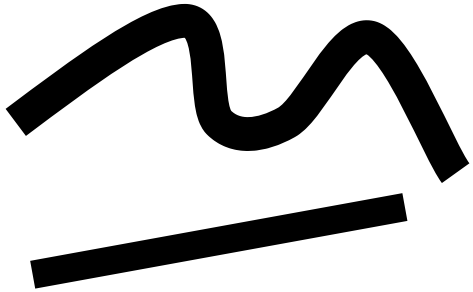
Typologie des graphiques

- Graphique = une surface plane à remplir

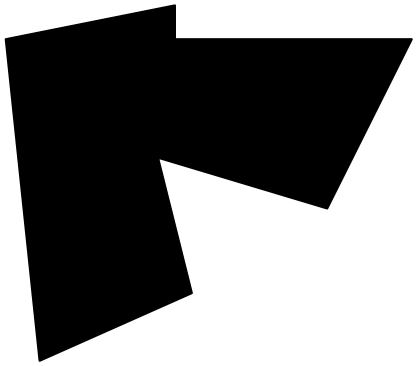
- 3 types de marques



points



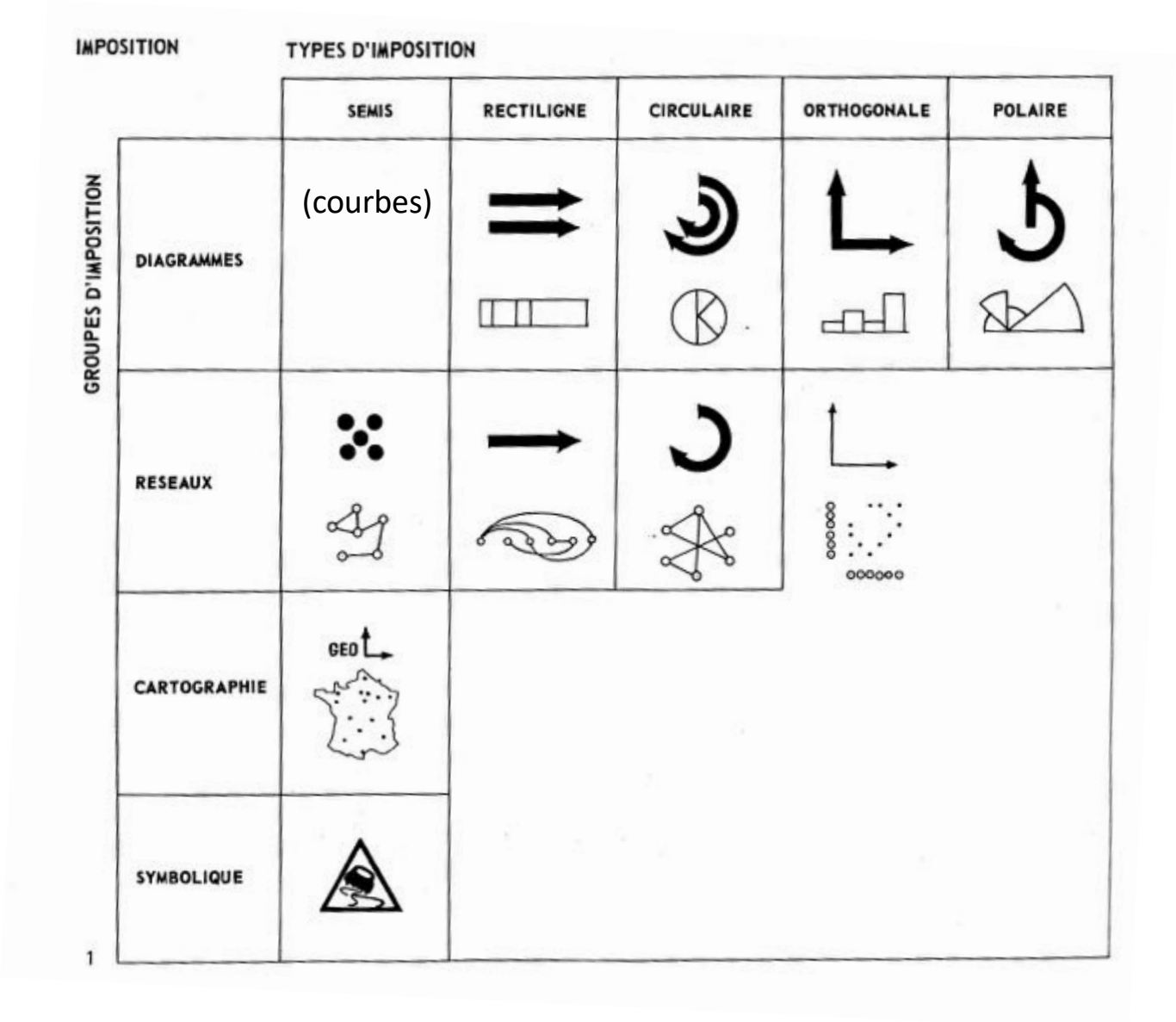
lignes
(droite)



zone (area, surface)

et la 3D ?

Comment on compose le graphique : imposition



[Bertin] p.52

efficacité ?

L'EFFICACITÉ est définie par la proposition suivante : Si pour obtenir une réponse correcte et complète à une question donnée, et toutes choses égales, une construction requiert un temps d'observation plus court qu'une autre construction, on dira qu'elle est plus efficace pour cette question.

[Bertin] p.139

rather than with their position on a vertical axis. Which presentation is more effective?

Unlike expressiveness, which only depends on the syntax and semantics of the graphical language, effectiveness also depends on the capabilities of the perceiver. The difficulty is that there does not yet exist an empirically verified theory of human perceptual capabilities that can be used to prove theorems about the effectiveness of graphical languages. Therefore, one must conjecture a theory of effectiveness that is both intuitively motivated and consistent with current empirically verified knowledge about human perceptual capabilities. This section

[Mackinlay] p.124

2. Vision pré-attentive

016543876297649387527896436906321987449075335644726889 56

combien de 2 ?

01654387629764

93875278964369

06321987449075

33564472688956

combien de 2 ?

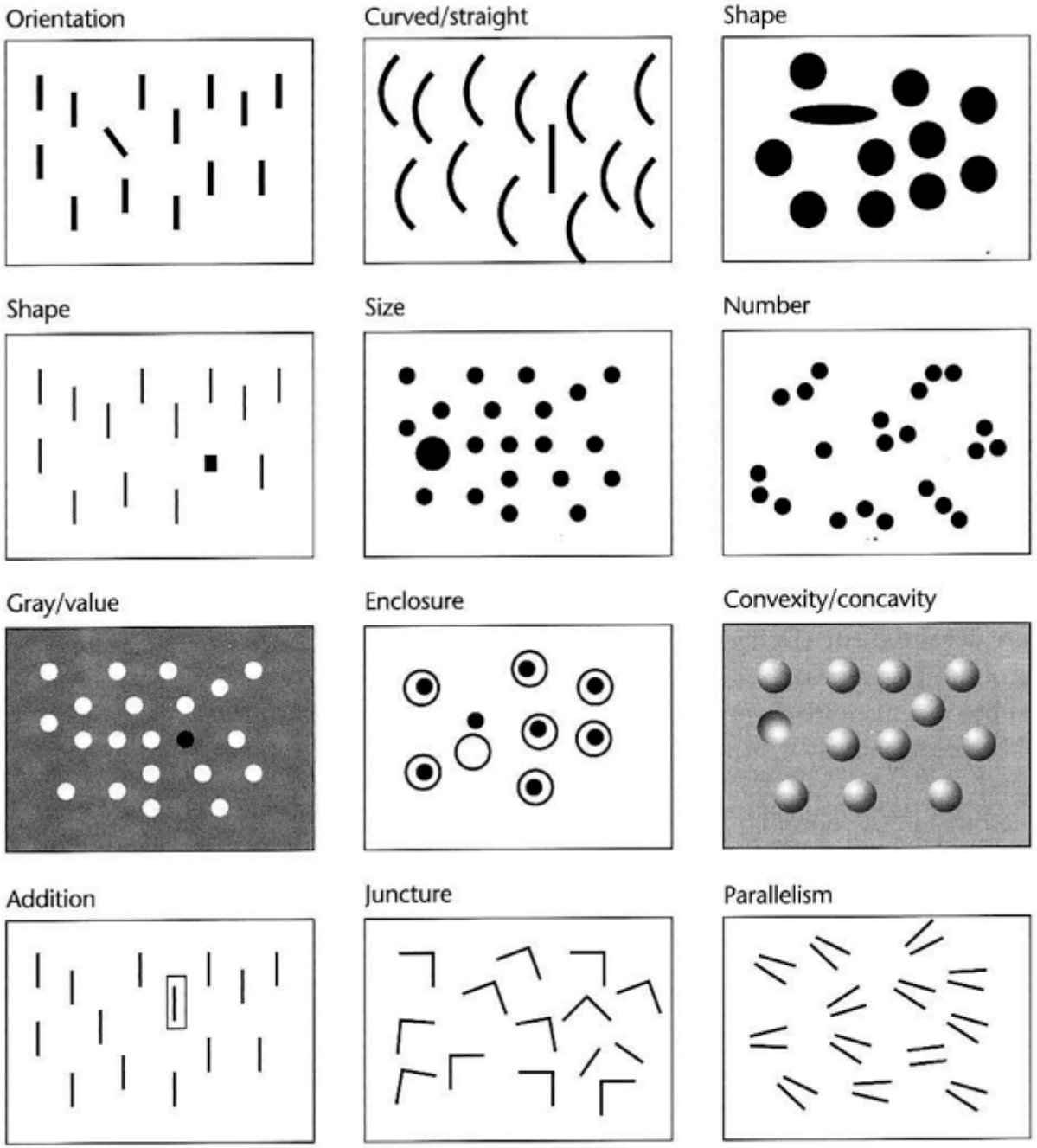
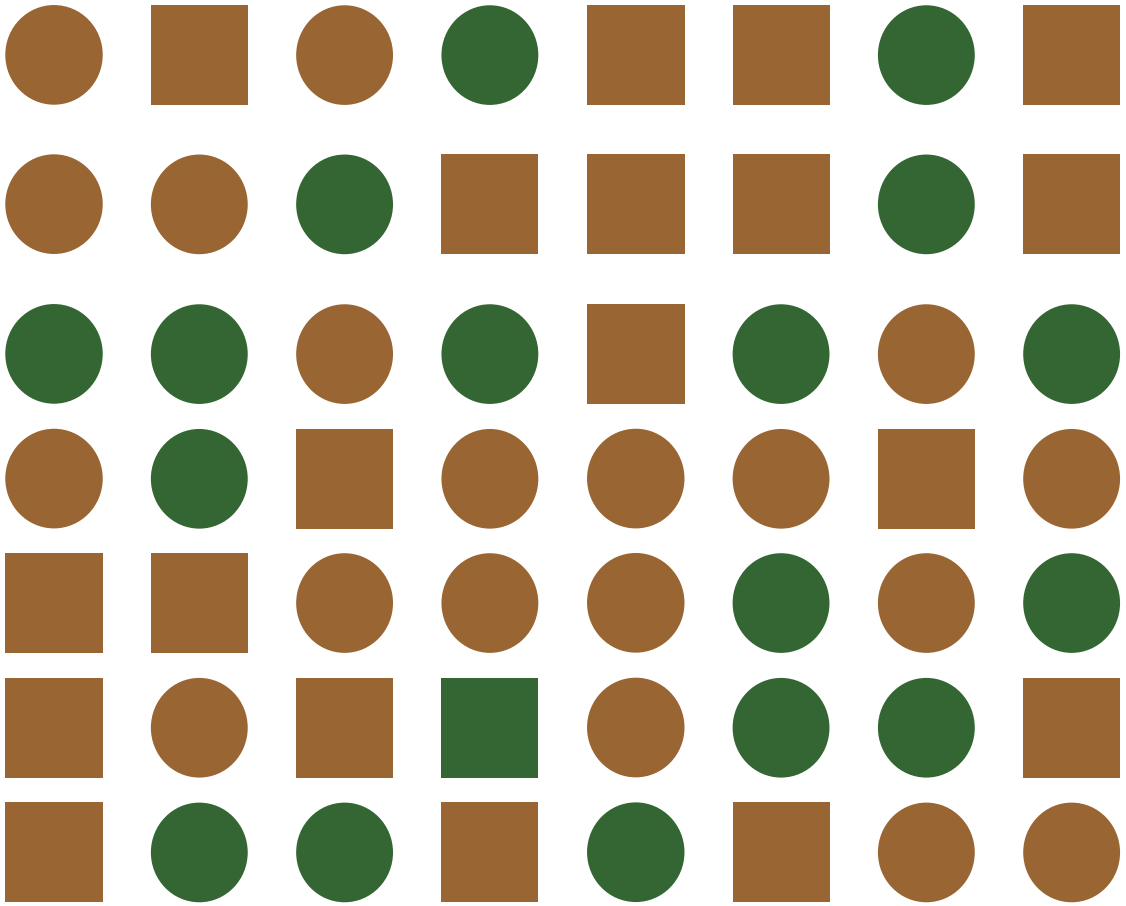
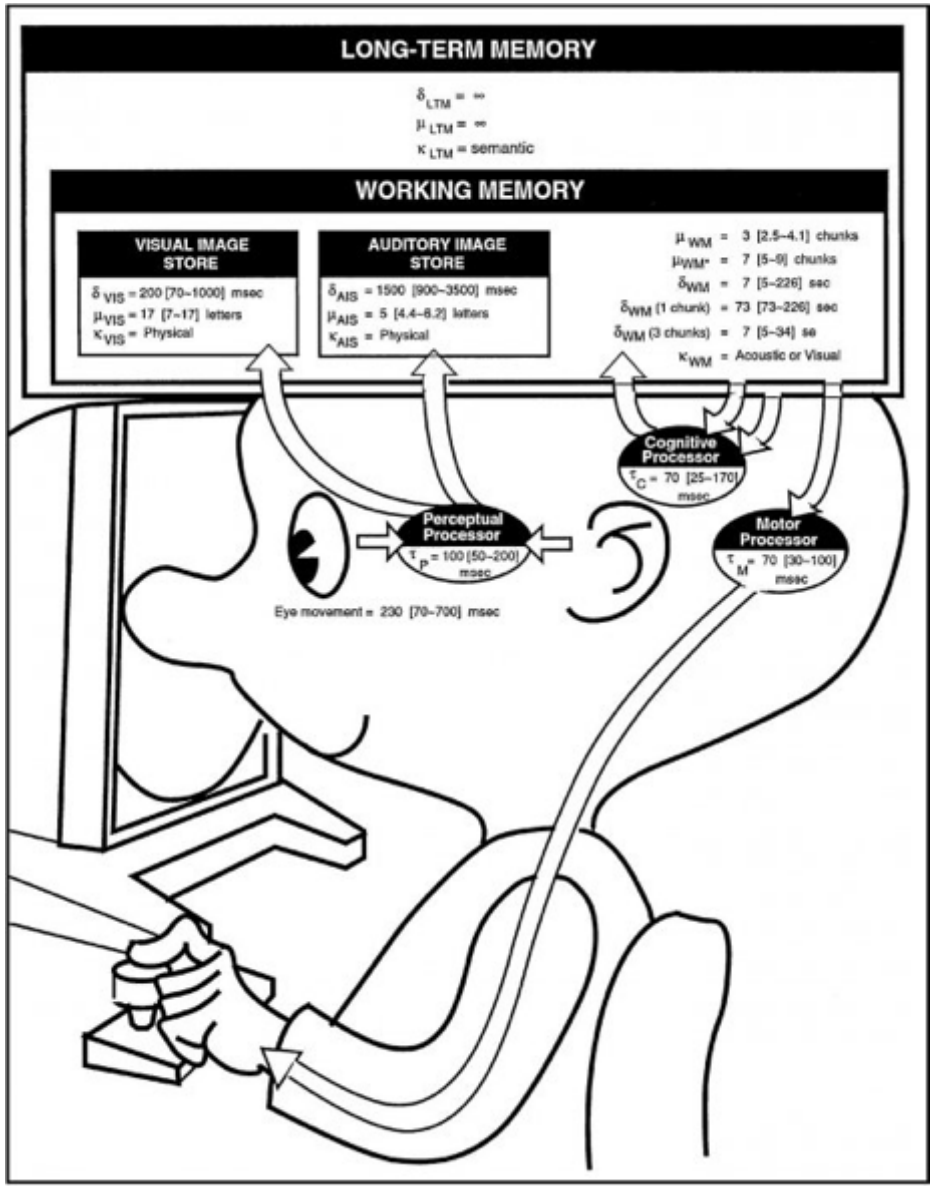


Figure 5.5 Most of the differences shown are preattentively distinguished. Only juncture and parallelism are not.

[Ware] p.153



limite du procédé : la conjonction de codes



Card, Moran, Newell
"The psychology of Human-Computer interaction"
1983

– 3 processeurs
- Perceptif
- Cognitif
- Moteur

– Hiérarchie de mémoire
- Mémoire de travail (RAM)
  Mémoire sensorielle
  Mémoire court terme
- Mémoire long terme

Mémoire court terme

- Un« bloc notes » pour retrouver rapidement les informations
- Temps de réponse rapide : 70ms mais décroît rapidement
- Capacité limitée : entre 5 et 9 items (chiffres, nombres, ...)

Psychological Review
Vol. 101, No. 2, 343-352

The Magical Number Seven, Plus or Minus Two
Some Limits on Our Capacity for Processing Information

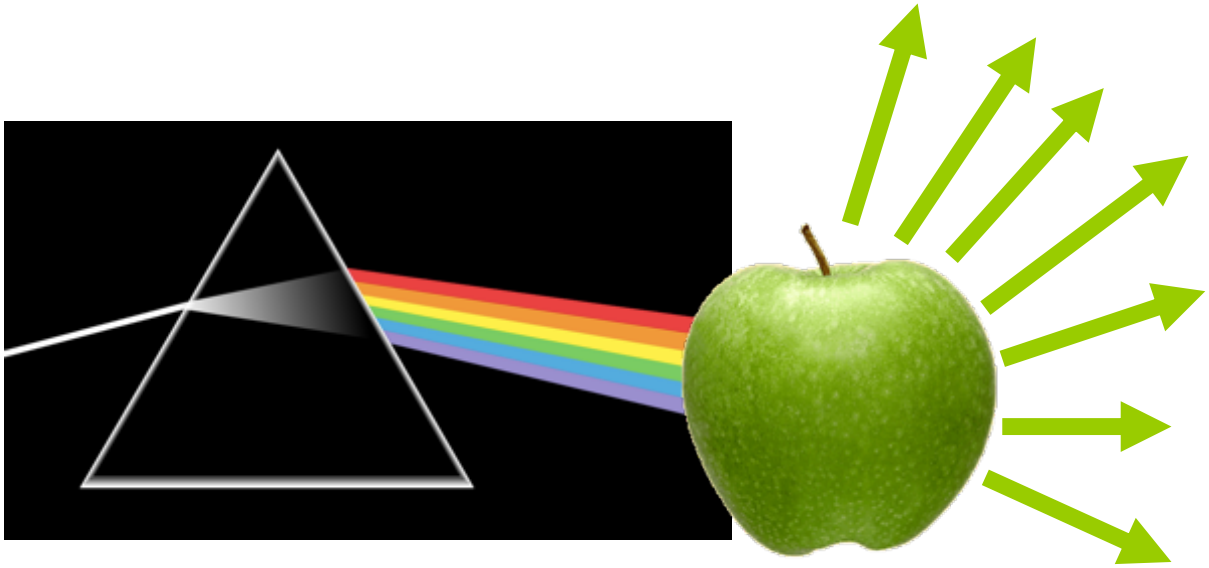
George A. Miller
Harvard University

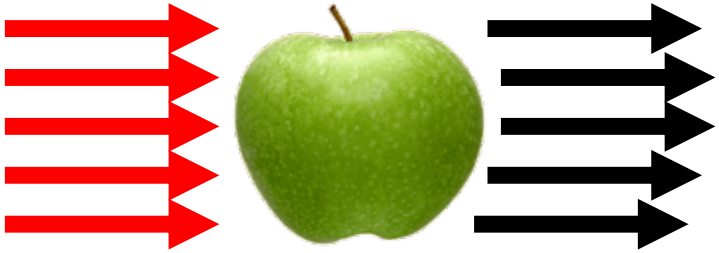
This paper was first read as an Invited Address before the Eastern Psychological Association in Philadelphia on April 15, 1955. Preparation of the paper was supported by the Harvard Psycho-Acoustic Laboratory under Contract N5ori-76 between Harvard University and the Office of Naval Research, U.S. Navy (Project NR 142-201, Report PNR-174). Reproduction for any purpose of the U.S. Government is permitted.
Received: May 4, 1955

My problem is that I have been persecuted by an integer. For seven years this number has followed me around, has intruded in my most private data, and has assaulted me from the pages of our most public journals. This number assumes a variety of disguises, being sometimes a little larger and sometimes a little smaller than usual, but never changing so much as to be unrecognizable. The persistence with which

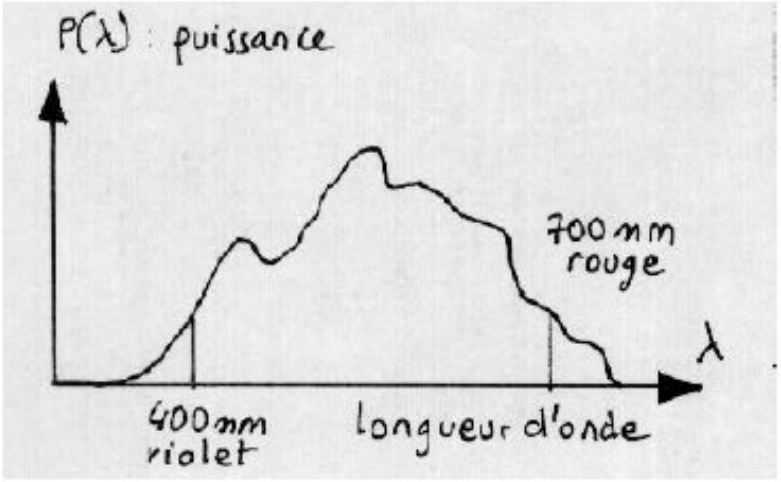
3. La couleur

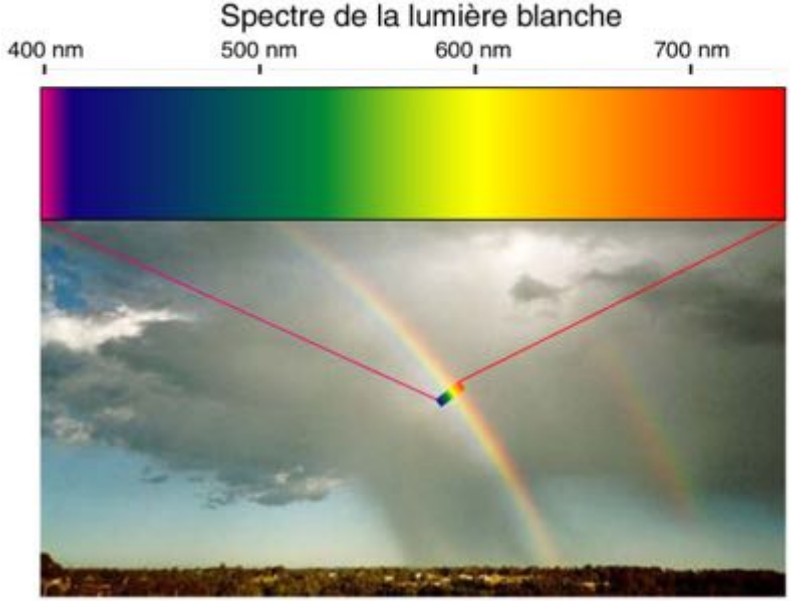
rappels de physique : l'interaction matière-lumière



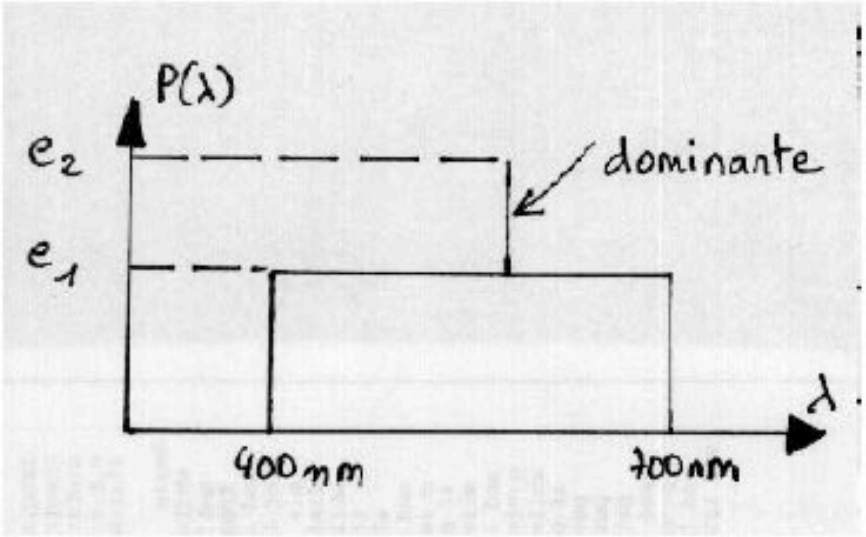


- Spectre d'une lumière colorée :





- Un modèle simple : 3 paramètres

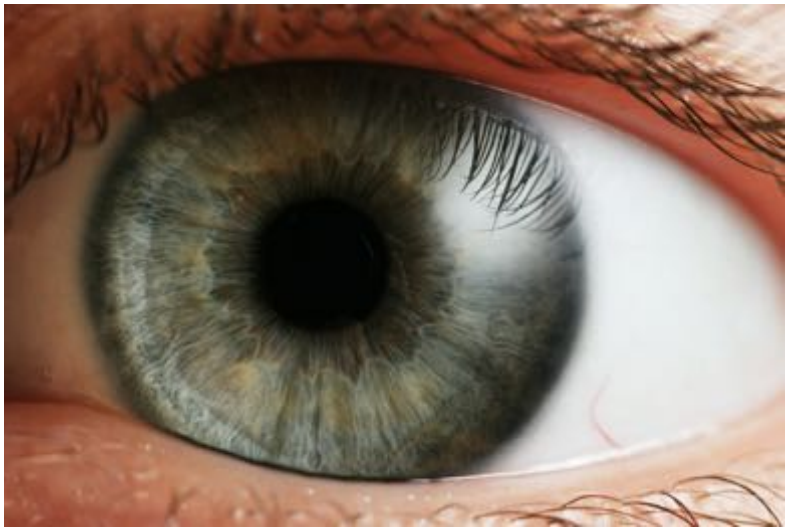


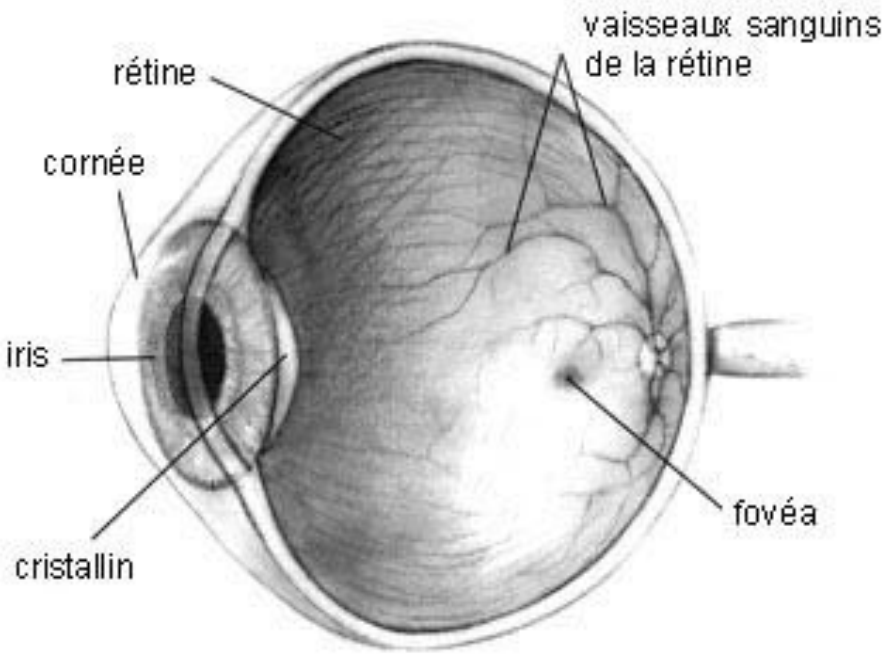
- Longueur d'onde dominante = > défini la teinte ("hue") de la couleur

- Degré de pureté = (e2-e1) / e2 * 100% => si 0% : lumière blanche, si 100% : lumière monochrome

- Facteur de clarté = surface du spectre = f(e1,e2) => puissance lumineuse totale ("luminance", "énergie", "intensité",…)

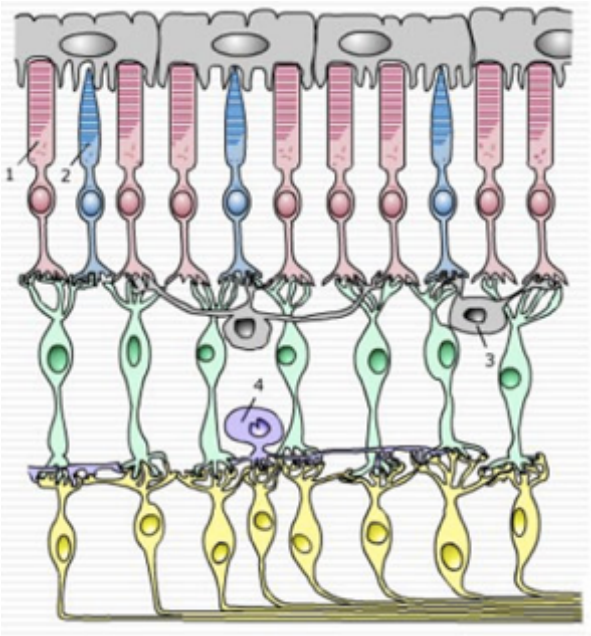
l'oeil



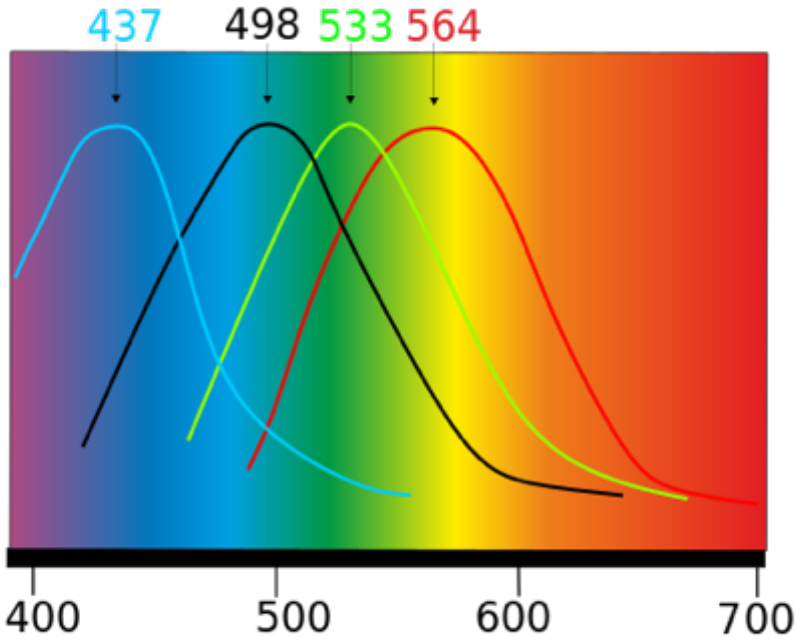


https://fr.wikipedia.org/wiki/Œil_humain

l'oeil



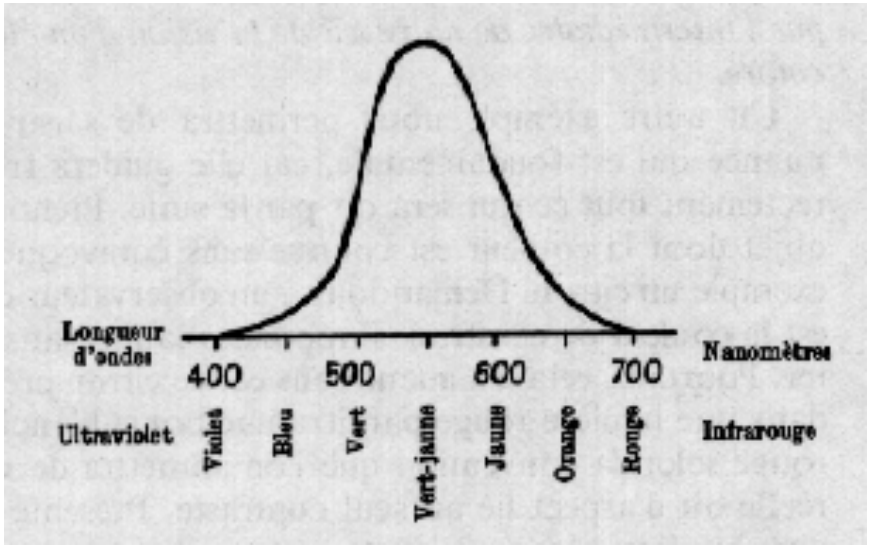
http://acces.ens-lyon.fr

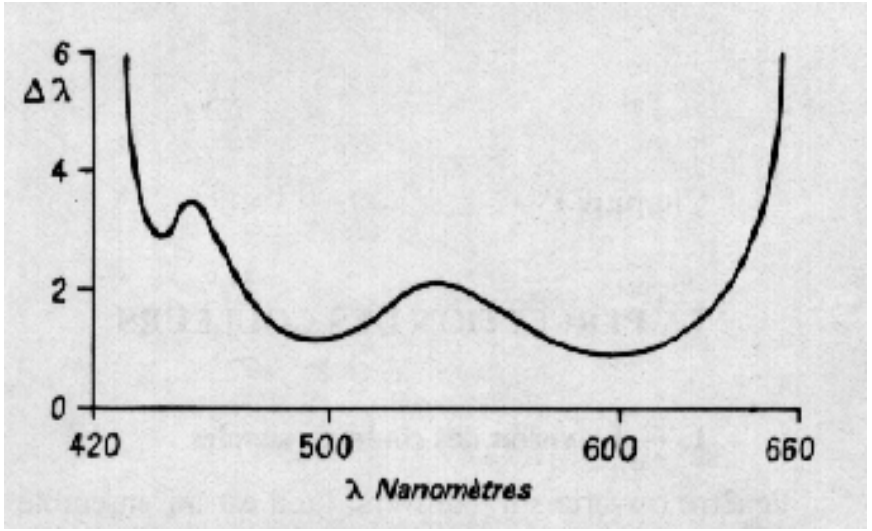


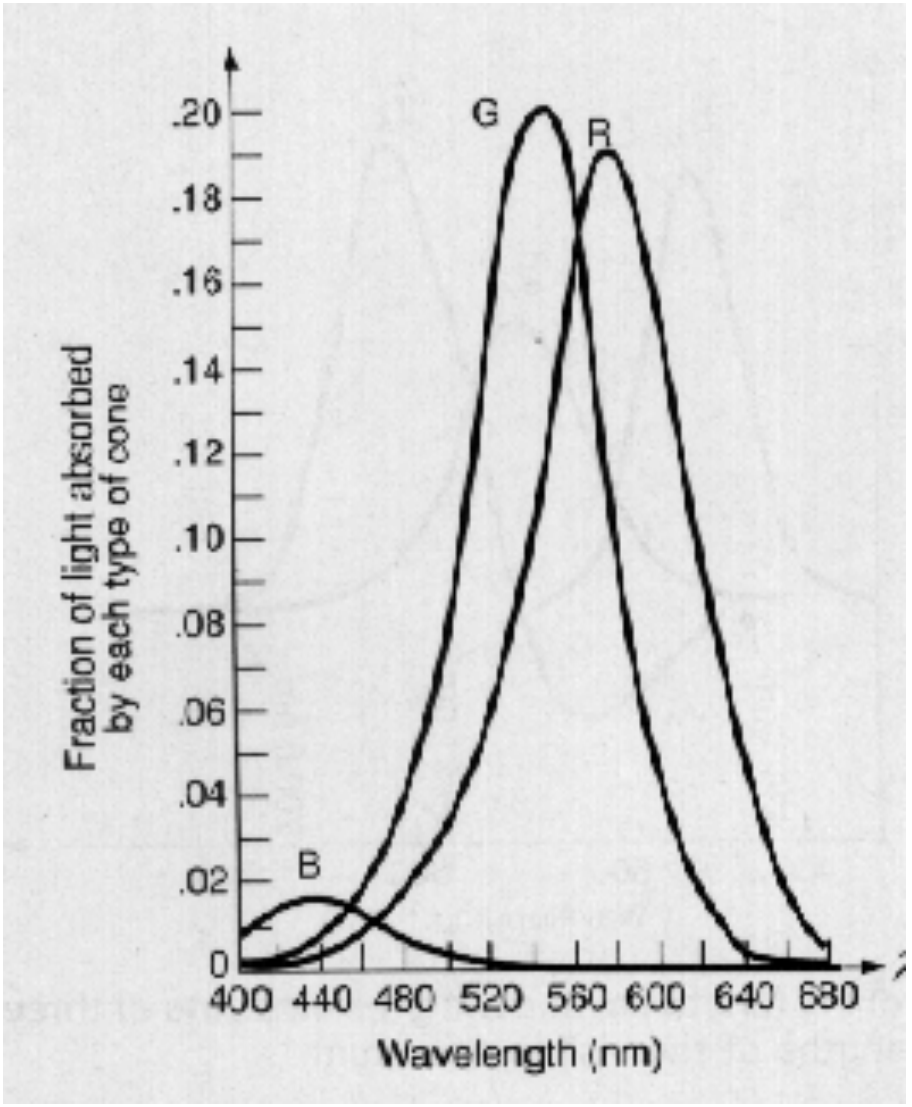
wikipedia (en noir : bâtonnets)

7M cônes, 120M bâtonnets

Inégale sensibilité des cônes





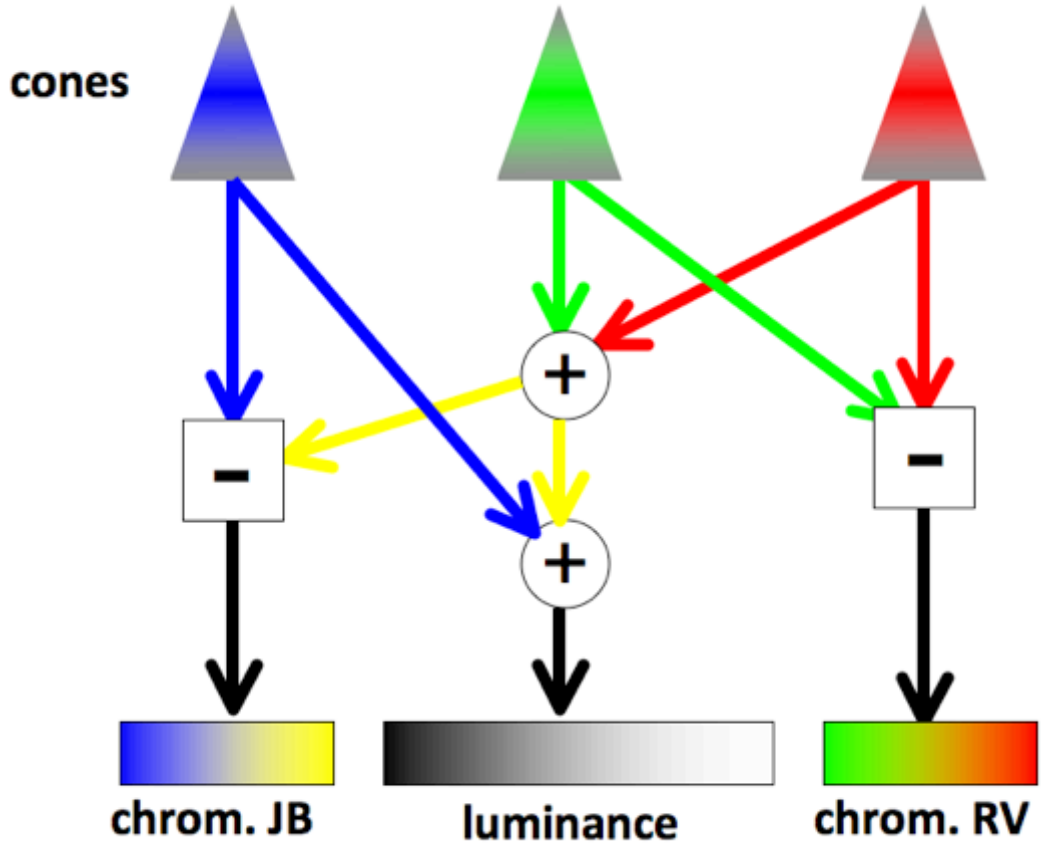


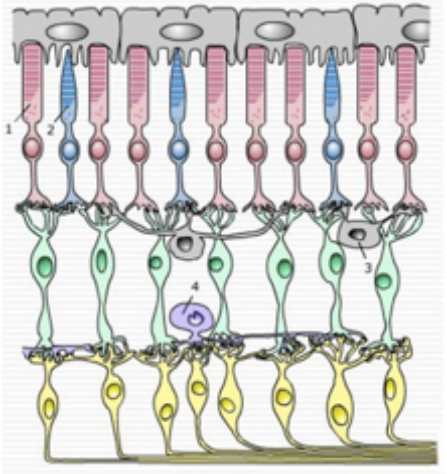
8% des hommes et 1% des femmes ont une forme de daltonisme

Normal vision *Deuteran* *Protan*

http://wearecolorblind.com

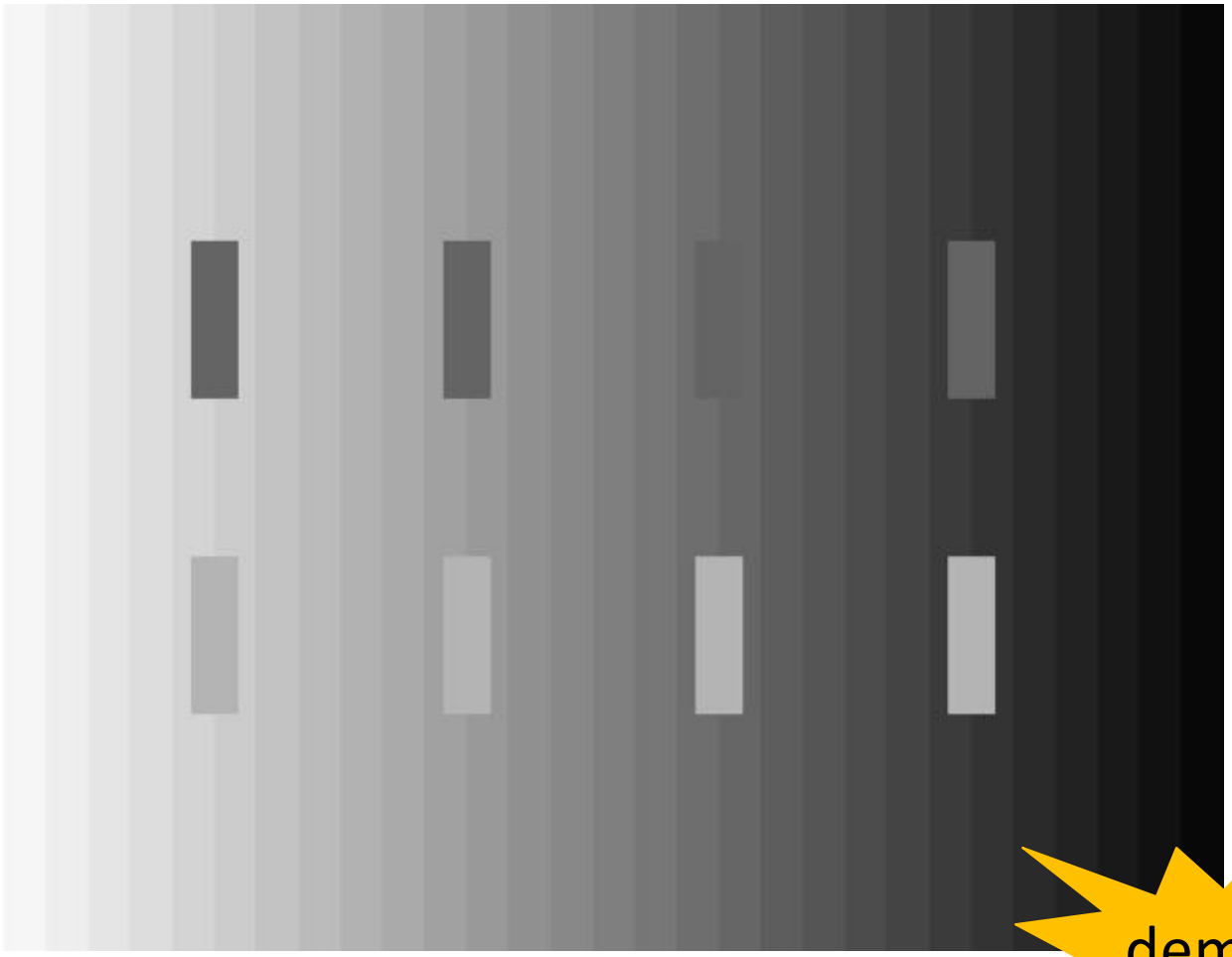
le modèle des couleurs opposées





(CIE L*A*B, YUV, oRGB ...)

Perception des contrastes

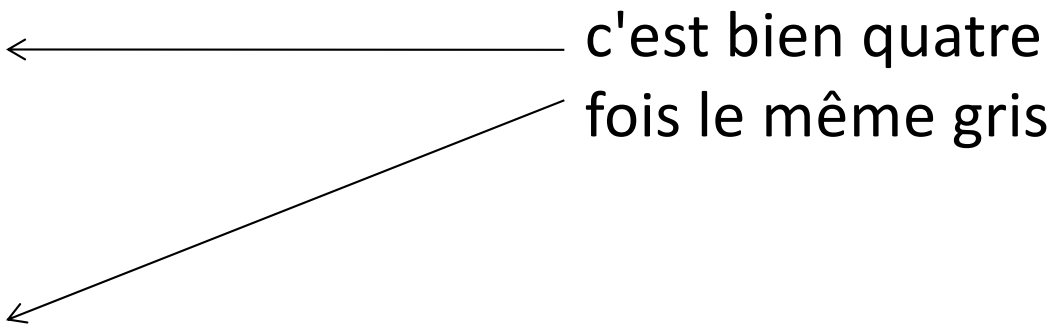


demo

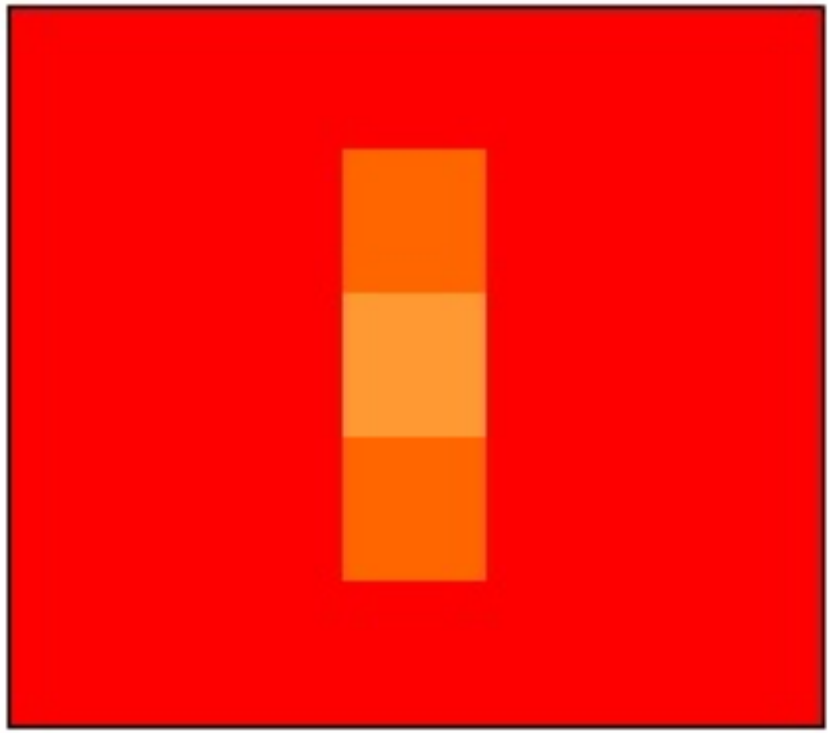
d'après [Ware]

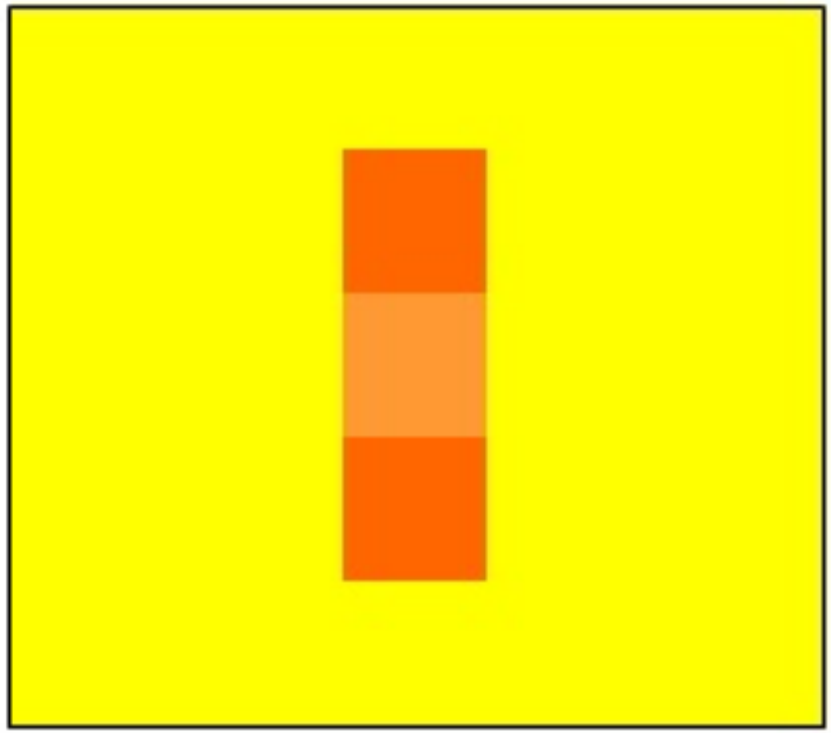
code Processing pour produire l'image

```
int N=40;
size(800,600);
noStroke();
for (int i=0; i<N;i++){
  fill(map(i,0,N,255,0));
  rect(i*width/float(N),0,width/N,height);
}
rectMode(CENTER);
fill(100);
rect(160,200,30,100);
rect(320,200,30,100);
rect(480,200,30,100);
rect(640,200,30,100);
fill(180);
rect(160,400,30,100);
rect(320,400,30,100);
rect(480,400,30,100);
rect(640,400,30,100);
save("contrastGRIS.png");
```



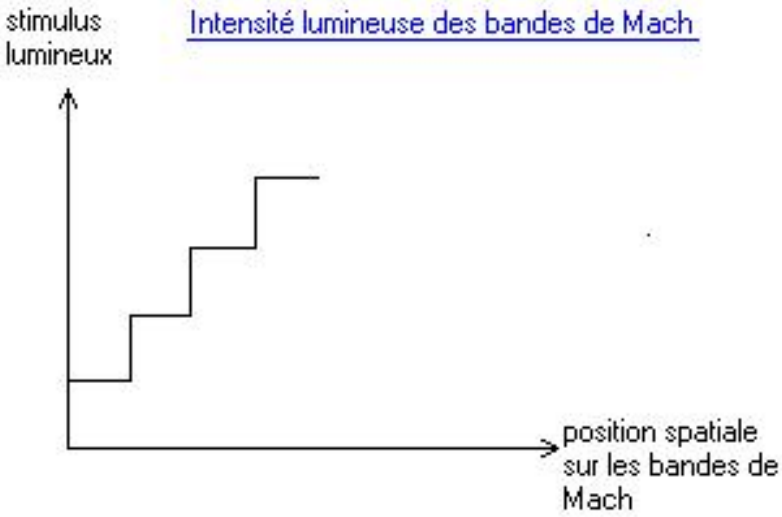
idem pour les couleurs

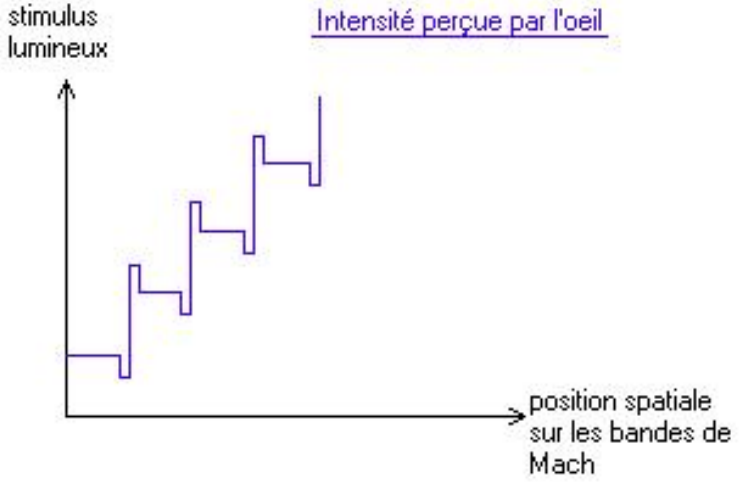




https://tpe-les-illusions-d-optique.webnode.fr/different-types-dillusions/illusions-de-couleurs/

Bandes de Mach



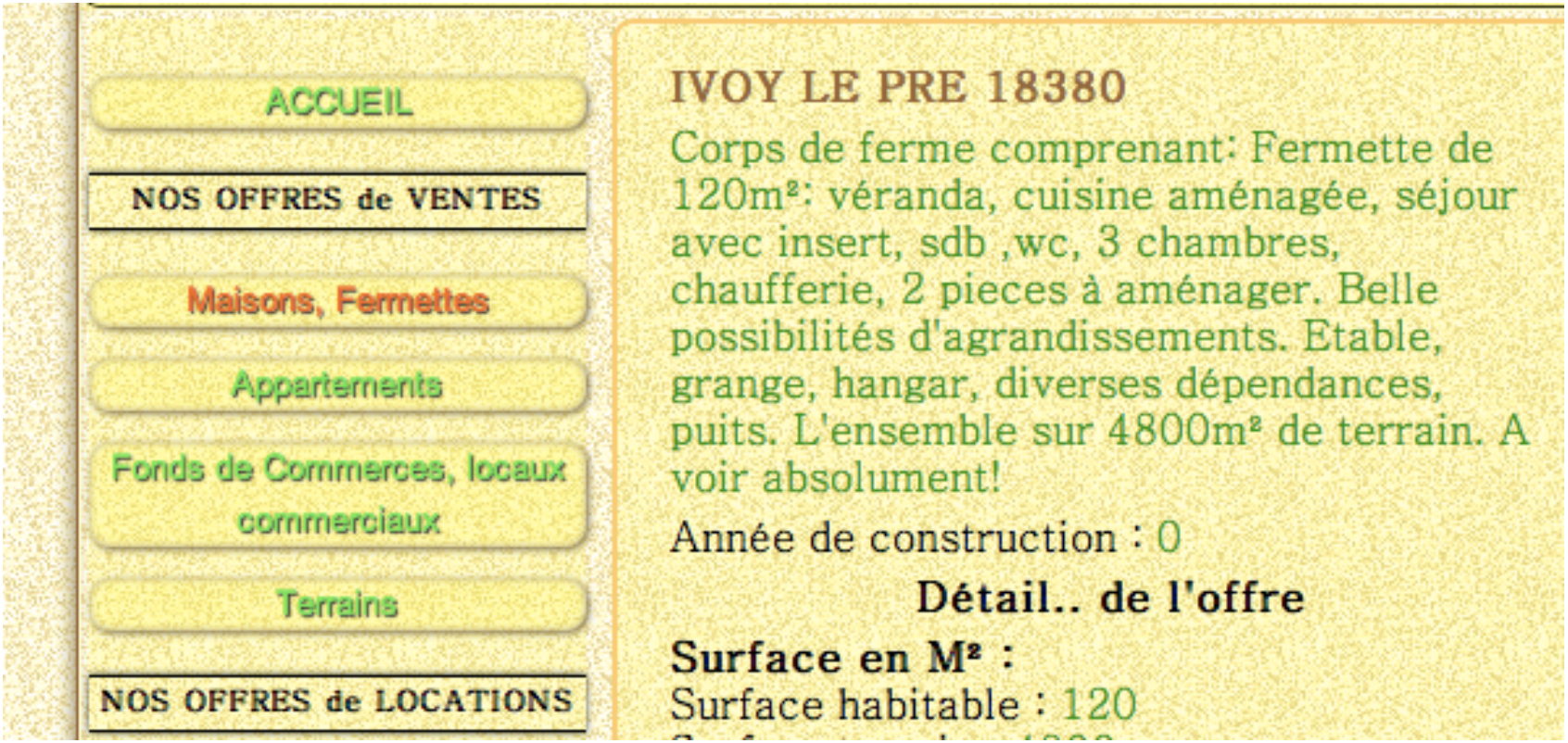


http://tecfa.unige.ch/tecfa/teaching/UVLibre/9900/bin26/mach.htm

Ecrans illisibles

http://asprise.com

Un autre



http://www.village-immobilier.com/

un excellent site

Color Usage Research Lab
NASA AMES RESEARCH CENTER

Using Color in Information Display Graphics
Design Methods, Color Science, and Color Guidelines

Design Process | Color Graphics Topics | Color Tool | Color Guidelines | Aerospace | Color Science | Utilities | Site Map

Home > Color Guidelines > Luminance Contrast Color Guidelines

LUMINANCE CONTRAST COLOR GUIDELINES

In terms of color usage, luminance contrast is the most important determinant of legibility of symbols and text, so it's no surprise that luminance contrast frequently appears in color guidelines. Most of the guidelines are directed at assuring sufficient contrast, and this is certainly a first-order concern. However, care must be taken to avoid *unnecessarily* limiting the designers' freedom to intentionally reduce luminance contrast in the interests of labeling and attention management.
More about Luminance Contrast.

The minimum luminance ratio between symbols and background shall be 3:1. Various forms of this guideline are nearly universal in guidance documents, differing mainly in the quantity required and in which statistical measure of luminance contrast is used. This is one of the most important usability issues related to color choices.

The problem it addresses is easily demonstrated. In spite of the large chromatic contrasts between the lines of text and the green background none is very legible at the point where the text and background luminances are equal. The black line has higher luminance contrast with the background and can be read (it would be even easier to read with a brighter green).

There is no question that this is an important problem, but there are a number of design issues involved that require further elaboration. When producing guidelines, caution is required to avoid such narrow wording as to interfere with good information management.

http://colorusage.arc.nasa.gov/

Production des couleurs

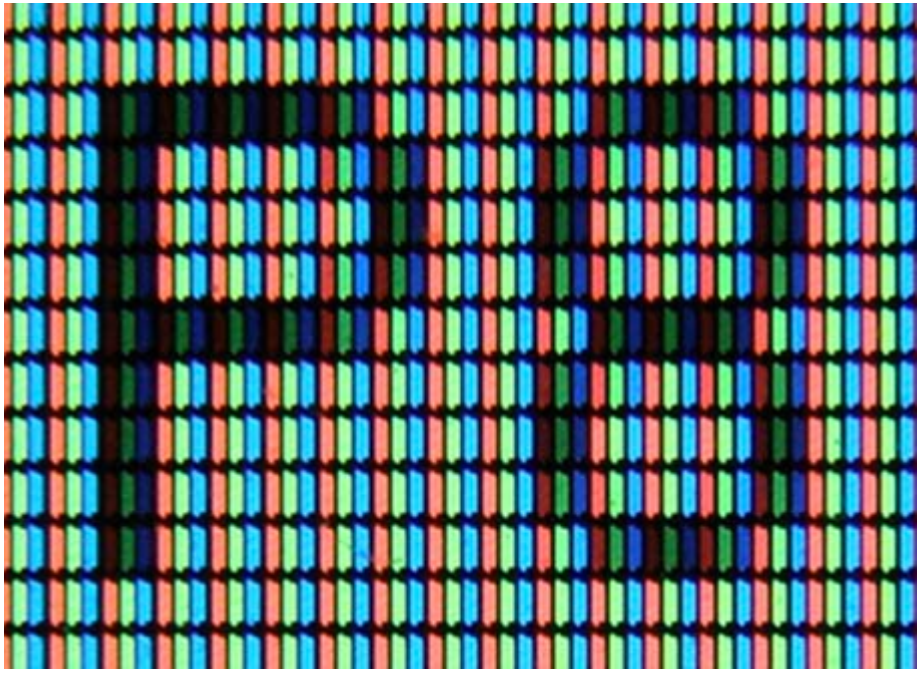
synthèse trichromatique

dosage additif
(projection)

dosage soustractif
(pigments)

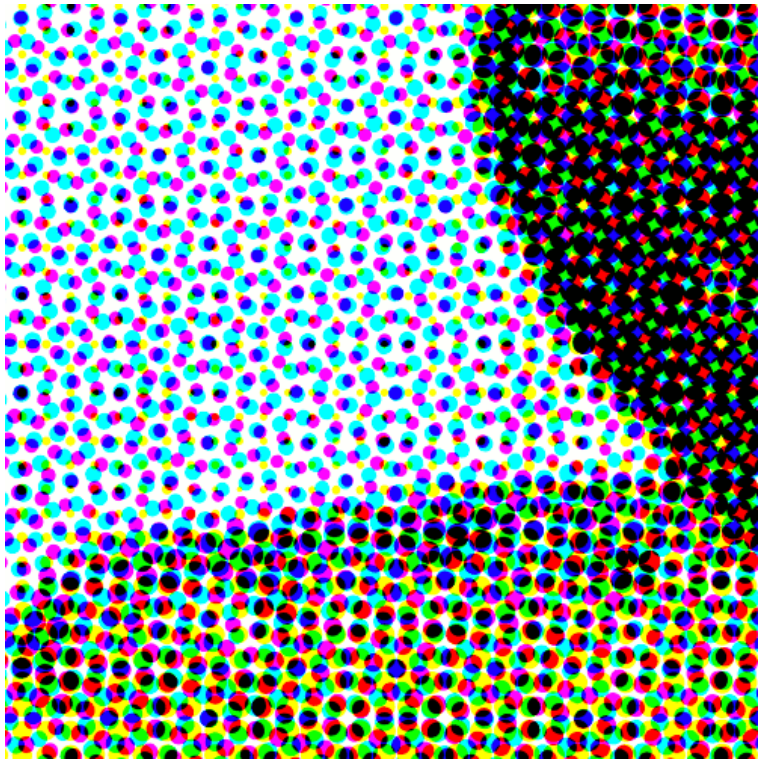
Mise en œuvre industrielle

RBV pour écrans :
- tubes à électron
- cristaux liquides
- LED



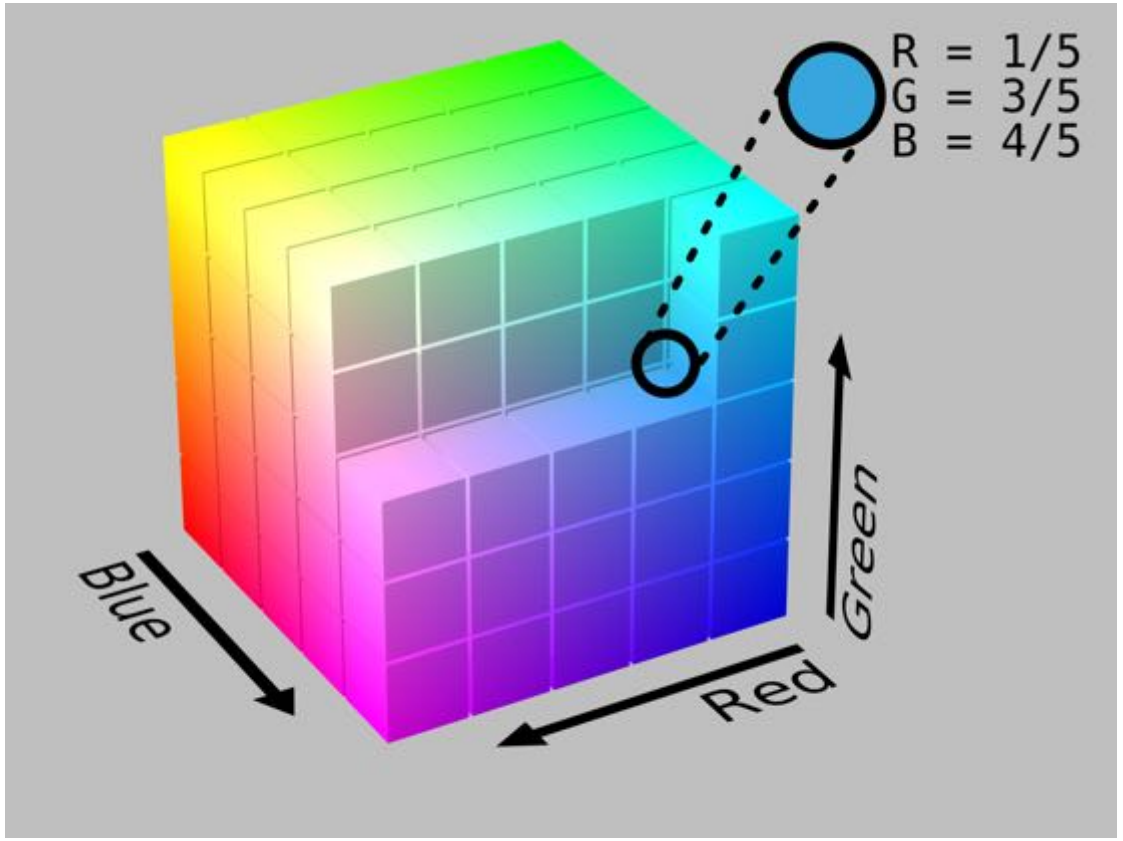
https://secouchermoinsbete.fr/33359-il-y-a-plus-petit-qu-un-pixel-sur-un-ecran?page=4

CMY pour imprimés :
utilisations de trames



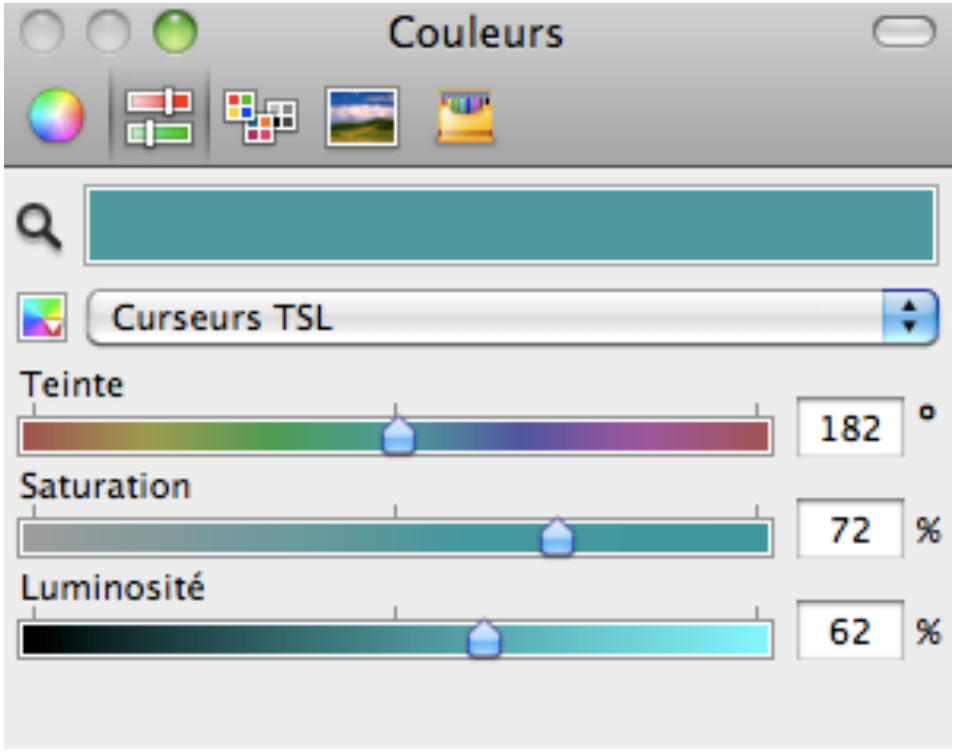
https://fr.wikipedia.org/wiki/Trame_(in
e)

Dosage des 3 primaires :
un problème fondamentalement tri-dimensionnel



https://en.wikipedia.org/wiki/Color_spaces_with_RGB_primaries#/media/File:RGB_Cube_Show_lowgamma_cutout_b.png

représentation TSL



Hue
Saturation
Value

A.R. Smith, conf. Siggraph'1978

formules de conversion RGB / HSV

```
procedure RGB_TO_HSV(r, g, b: real; var h, s, v: real)
  {Given: r, g, b, each in [0, 1]}
  {Desired: h in [0, 360), s and v in [0, 1], except if s = 0,
    then h = undefined which is a defined constant whose value is outside the
    interval [0, 360]}
begin
  max := MAXIMUM(r, g, b);
  min := MINIMUM(r, g, b);
  v := max;                                  {value}
  if max <>0
    then s := (max - min)/max                {saturation}
    else s := 0;
  if s = 0
    then h := undefined
    else                                     {saturation not zero, so determine hue}
      begin
        rc := (max - r)/(max - min);         {rc measures "distance" of color
                                               from red}
        gc := (max - g)/(max - min);
        bc := (max - b)/(max - min);
        if      r = max then h := bc - gc    {resulting color between
                                               yellow and magenta}
        else if g = max then h := 2 + rc - bc {resulting color between cyan
                                               and yellow}
        else if b = max then h := 4 + gc - rc; {resulting color between
                                               magenta and cyan}
        h := h*60;                           {convert to degrees}
        if h < 0 then h := h + 360           {make nonnegative}
      end     {chromatic case}
end     {RGB_TO_HSV}
```

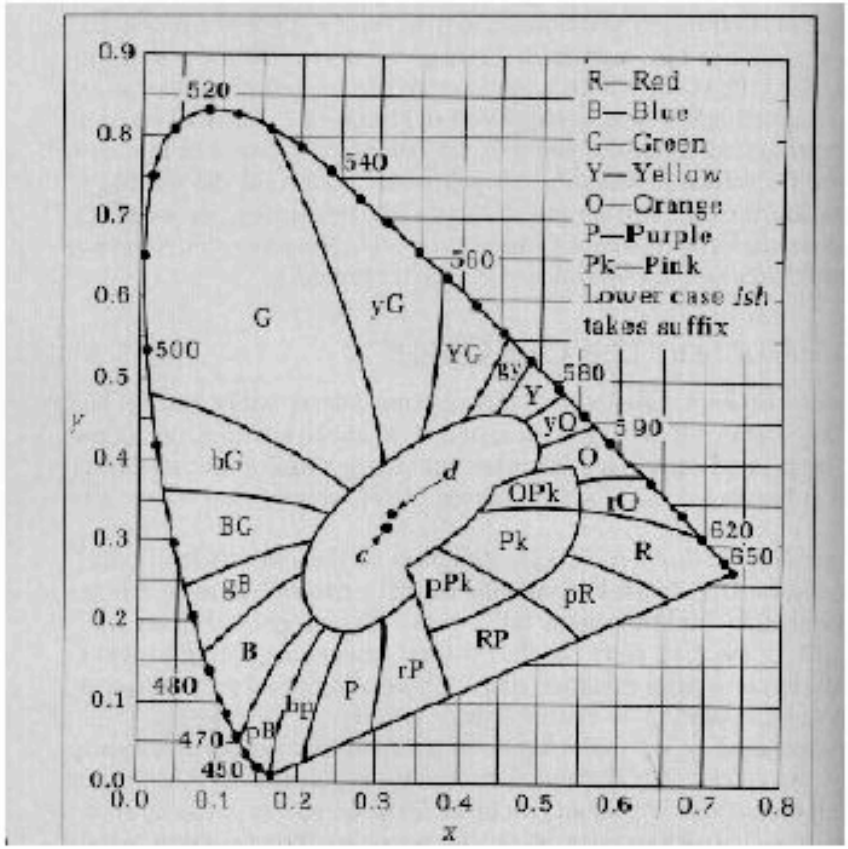
```
procedure HSV_TO_RGB(var r, g, b: real; h, s, v: real);
  {Given: h in [0, 360] or undefined, s and v in [0, 1]}
  {Desired: r, g, b, each in [0, 1]}
begin
  if s = 0
    then                                     {achromatic color: there is no hue}
      if h = undefined
        then
          begin                              {this is the achromatic case}
            r := v;
            g := v;
            b := v
          end
        else ERROR                           {error if s = 0 and h has a value}
    else                                     {chromatic color: there is a hue}
      begin
        if h = 360 then h := 0;
        h := h/60;                           {h is now in [0, 6)}
        i := FLOOR(h);                       {largest integer <= h}
        f := h - i;                          {fractional part of h}
        p := v*(1 - s);
        q := v*(1 - (s*f));
        t := v*(1 - (s*(1 - f)));
        case i of
          0: (r, g, b) := (v, t, p);         {triplet assignment}
          1: (r, g, b) := (q, v, p);
          2: (r, g, b) := (p, v, t);
          3: (r, g, b) := (p, q, v);
          4: (r, g, b) := (t, p, v);
          5: (r, g, b) := (v, p, q);
        end     {case}
      end     {hue}
end     {HSV_TO_RGB}
```

Foley & van Dam. Fundamentals of interactive computer graphics, 1983, p.615

Diagramme "fer à cheval" de la CIE (1931)

- On peut résumer en une courbe en 2D :

$$x + y + z = 1 \Rightarrow z = 1 - x - y$$



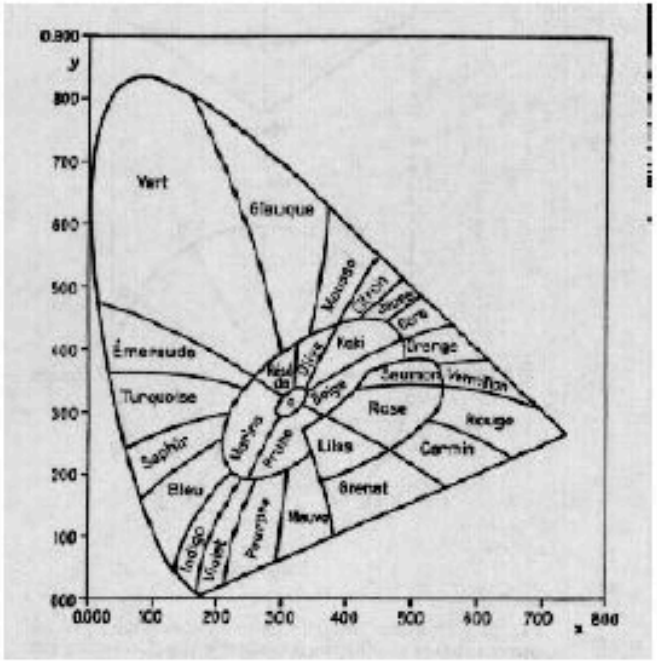
[HILL] p. 572

- Désignation des couleurs

en minuscule "-âtre" ou "-ish"

yG = yellow-ish, green

= jV = jaunâtre-vert = Glauque



[DERIBERE] p. 111

http://www.cie.co.at/

Le gamut

• Les appareils de visualisation (moniteur, imprimantes, films) ont des couleurs primaires a priori différentes

• Le "blanc" correspondant est donc différent. Parfois réglable :

Exemple : écran Macintosh 17" trinitron

9300K => blanc bleuté "froid"

6500K => blanc "normal" correspondant au centre du diagramme CIE (corps noir porté à 6504K)

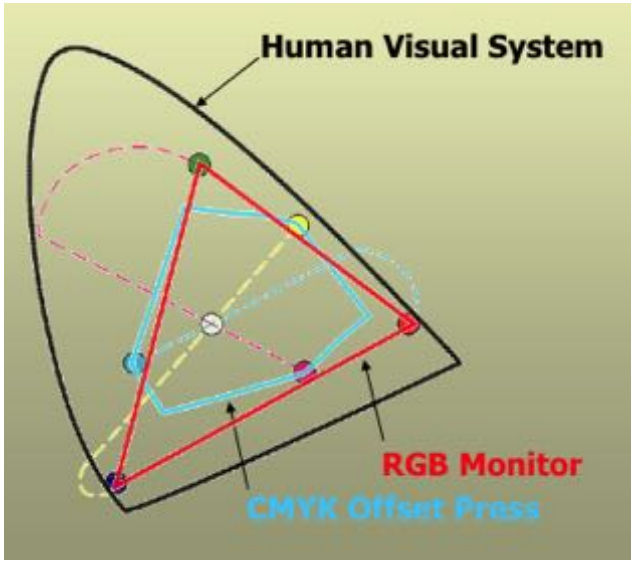
5000K => blanc rougeâtre "chaud"

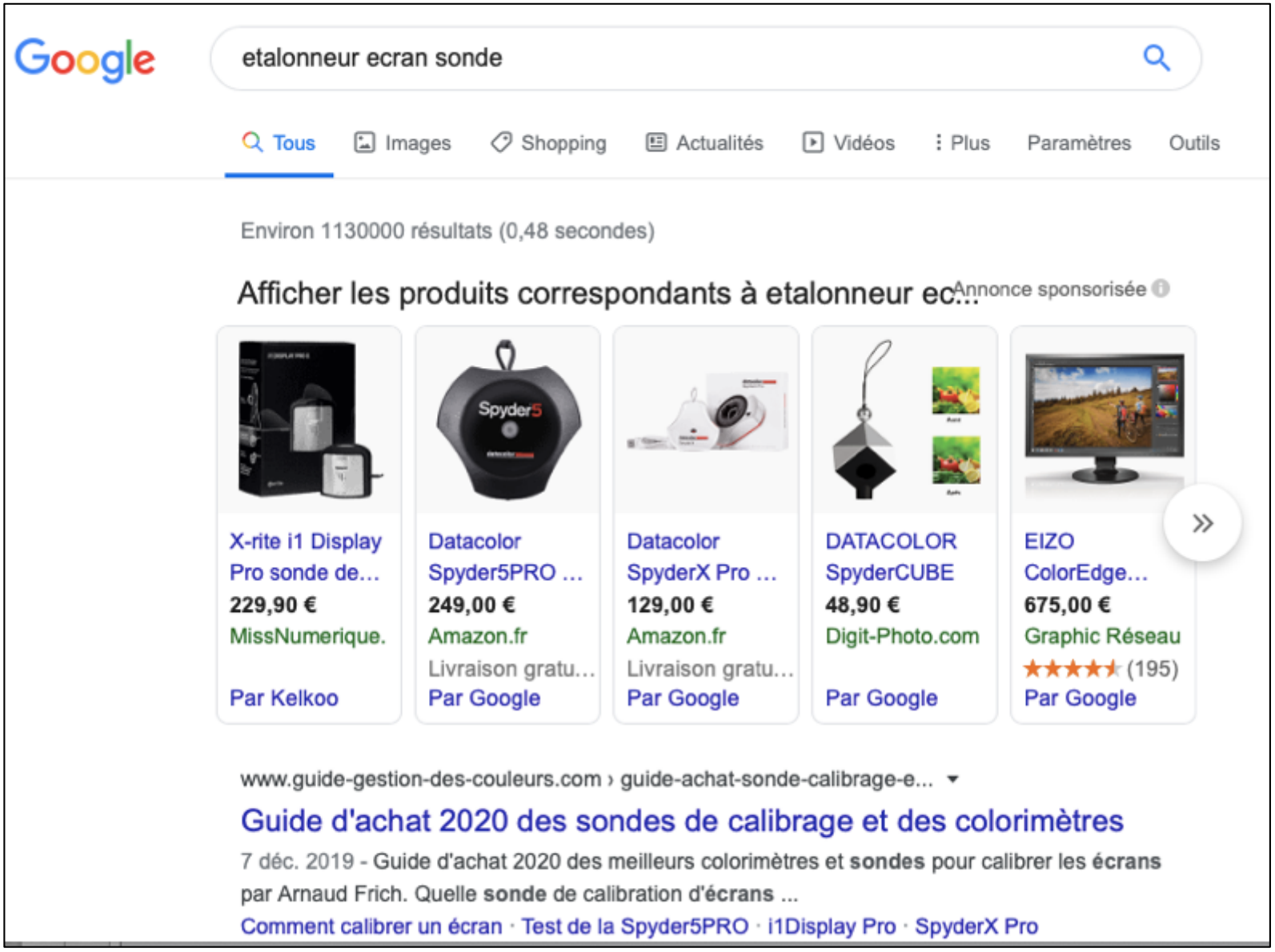
• Les coordonnées de ces trois primitives dans le diagramme CIE définissent le gamut de l'appareil (triangle)

Devrait être fourni par le fabricant…

• Toutes les couleurs à l'intérieur du triangle peuvent être reproduites par l'appareil.

• Mais il faut faire attention quand on change d'appareil (moniteur => imprimante)




Google
etalonneur ecran sonde
Tous
Images
Shopping
Actualités
Vidéos
Plus
Paramètres
Outils
Environ 1130000 résultats (0,48 secondes)
Afficher les produits correspondants à etalonneur ec...
Annonce sponsorisée
Spyder5
X-rite i1 Display Pro sonde de...
229,90 €
MissNumerique.
Par Kelkoo
Datacolor Spyder5PRO ...
249,00 €
Amazon.fr
Livraison gratu...
Par Google
Datacolor SpyderX Pro ...
129,00 €
Amazon.fr
Livraison gratu...
Par Google
DATACOLOR SpyderCUBE
48,90 €
Digit-Photo.com
Par Google
EIZO ColorEdge...
675,00 €
Graphic Réseau
(195)
Par Google
www.guide-gestion-des-couleurs.com › guide-achat-sonde-calibrage-e...
Guide d'achat 2020 des sondes de calibrage et des colorimètres
7 déc. 2019 - Guide d'achat 2020 des meilleurs colorimètres et sondes pour calibrer les écrans par Arnaud Frich. Quelle sonde de calibration d'écrans ...
Comment calibrer un écran · Test de la Spyder5PRO · i1Display Pro · SpyderX Pro

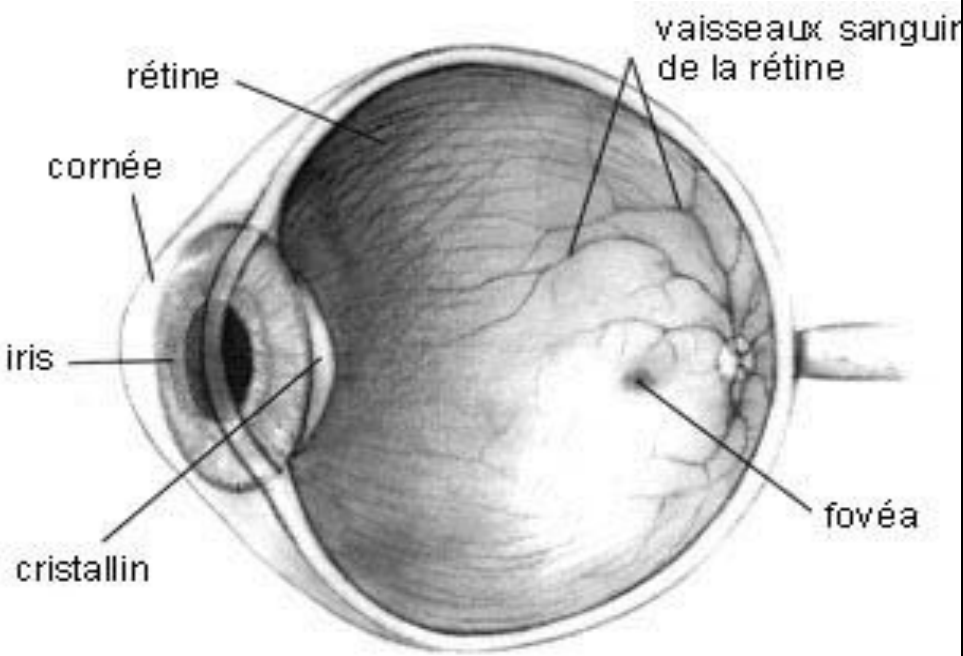
4. La lisibilité

alternances
saccades : ± 25 ms
fixations : ± 250 ms

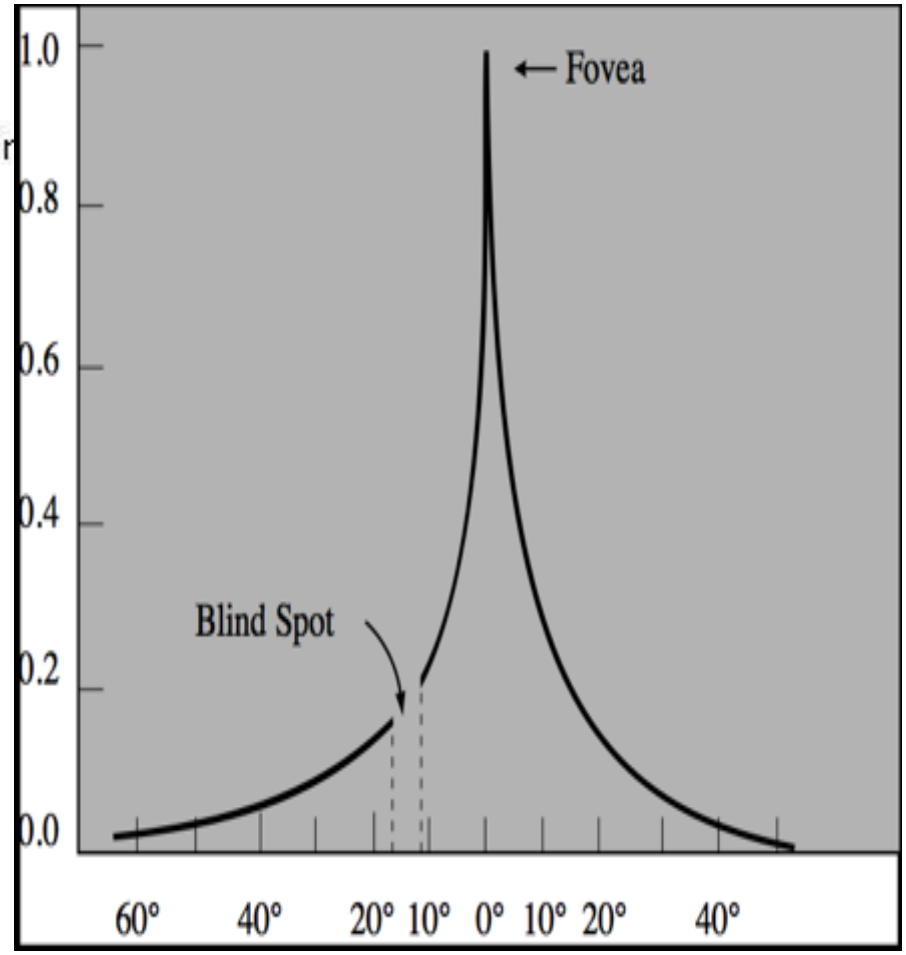
When a person is reading a sentence silently, the eye movements show that not every word is fixated. Every once in a while a regression (an eye movement that goes back in the text) is made to re-examine a word that may have not been fully understood the first time. This only happens with about 10% of the fixations, depending on how difficult the text is. The more difficult the higher the likelihood that regressions are made.

http://www.scholarpedia.org/article/Eye_movements

L'oeil humain (bis)

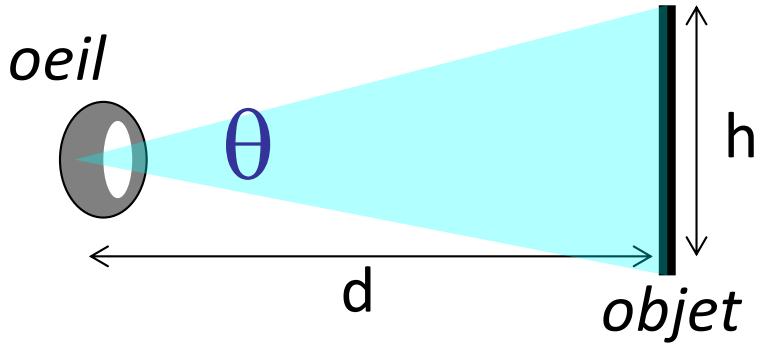


(wikipedia)



acuité / angle de vue

Acuité

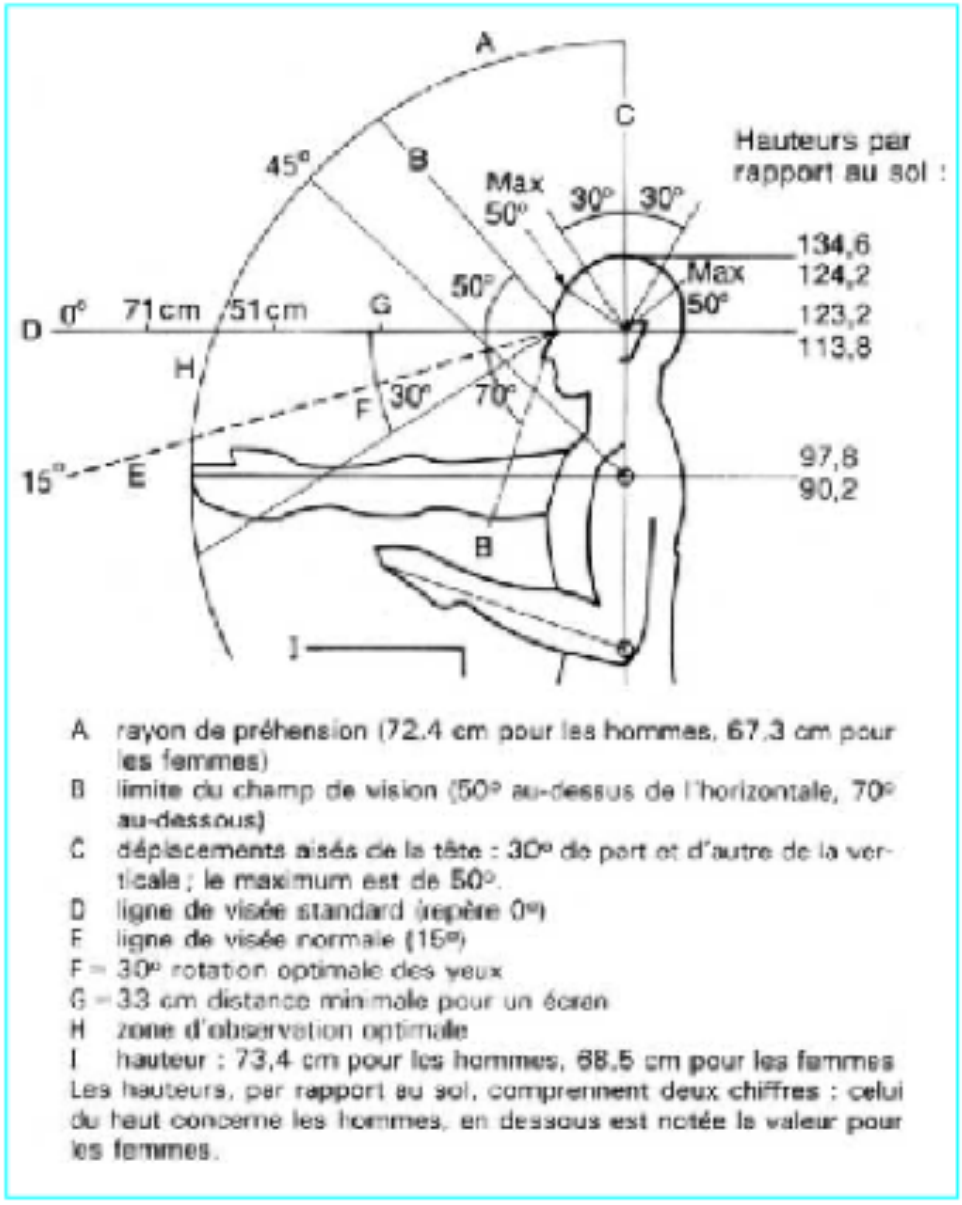


$\tan(\theta/2)=h/d \Rightarrow \theta$

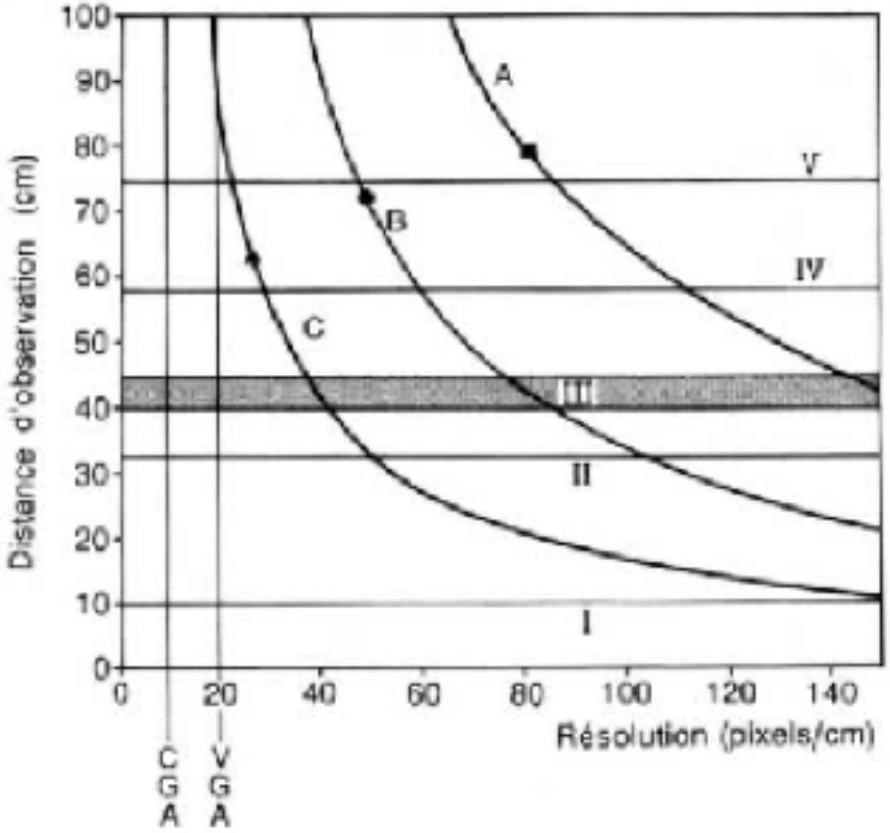
points ●● 1 min. arc = 1' = 1/60°

traits ||||| 1' à 2'

lettres **LCXY** 5' (20/20 si reconnu à 90%)



A rayon de préhension (72,4 cm pour les hommes, 67,3 cm pour les femmes)
B limite du champ de vision (50° au-dessus de l'horizontale, 70° au-dessous)
C déplacements aisés de la tête : 30° de part et d'autre de la verticale ; le maximum est de 50°.
D ligne de visée standard (repère 0°)
F ligne de visée normale (15°)
F = 30° rotation optimale des yeux
G = 33 cm distance minimale pour un écran
H zone d'observation optimale
I hauteur : 73,4 cm pour les hommes, 68,5 cm pour les femmes
Les hauteurs, par rapport au sol, comprennent deux chiffres : celui du haut concerne les hommes, en dessous est notée la valeur pour les femmes.



A optimum d'acuité visuelle de 1'
B acuité visuelle de 2'
C acuité visuelle de 4'
I distance minimale d'accommodation pour un enfant de 10 ans
II distance de lecture minimale pour un adulte
III (en grisé) distance d'observation recommandée
IV longueur moyenne des bras
V longueur maximale des bras
CGA *color graphic adapter*
VGA *video graphic adapter*

Alain COUSIN. Restitution des images - Notions de base sur les écrans. Techniques de l'ingénieur E5650

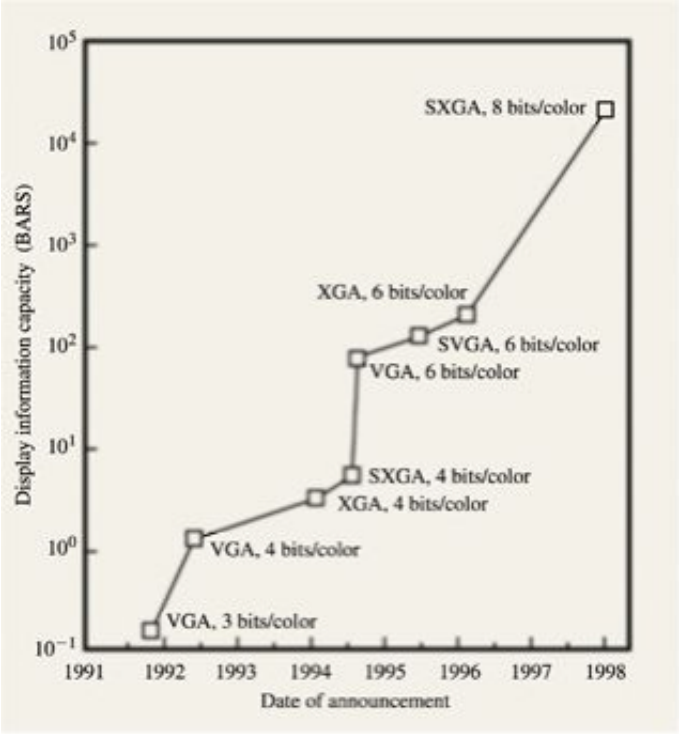


Figure 2

Information capacity increase of IBM TFT/LC displays with time. Information capacity is in units of pixel count times number of colors (billions of addressable retinal stimuli, or BARS).

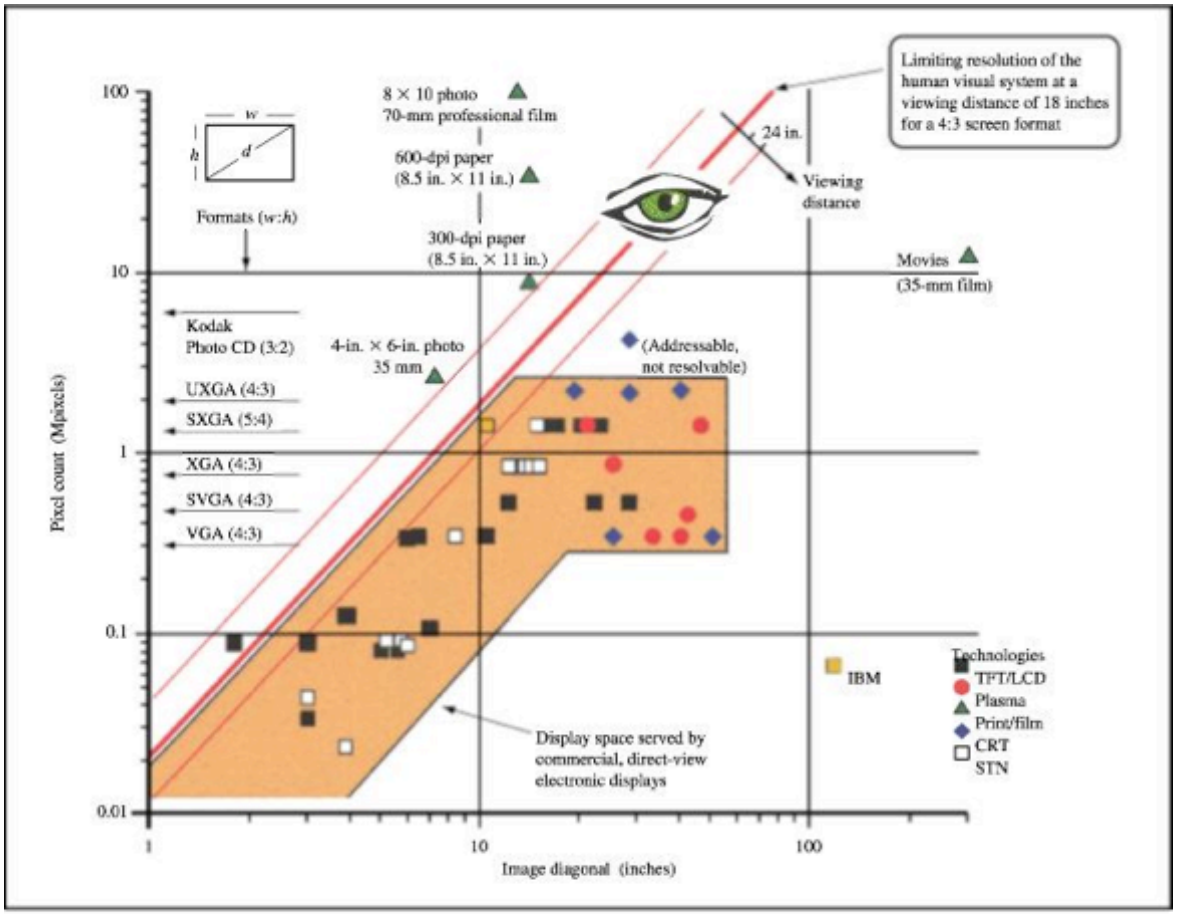


Figure 1

A view of display space showing existing electronic, paper, and film displays.

P. M. Alt, K. Noda. Increasing electronic display information content: An introduction.
IBM J. of Res. & Dev. Volume 42, Numbers 3/4, 1998.

1998 : 150 dpi (IBM)
2013 : 469 dpi (HTC One)

Taille du texte sur les écrans ?

Nous conclurons cet article en vous proposant un comparatif entre les différentes résolutions, **densités de pixels** et **tailles de polices** recommandables en fonction de la distance de lecture "normale".

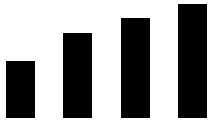
Distance en cm	Taille minimale	Densité de l'appareil	Taille minimale
30 (mobile)	1,68 mm	264	25px ≈ 12pt
40 (tablette sur jambes)	2,2 mm	264	33px ≈ 16pt
50 (ordinateur de bureau)	2,8 mm	96	12px ≈ 9pt
60 (ordinateur de bureau)	3,4 mm	96	13px ≈ 10pt
70 (ordinateur de bureau)	4 mm	96	15px ≈ 11pt
80 (ordinateur de bureau)	4,5 mm	96	17px ≈ 13pt

https://www.usabilis.com/choisir-taille-police/

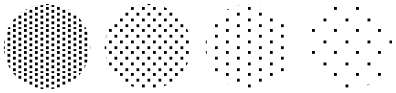
5. Choix des attributs graphiques

Classification de Bertin (1965)

Variables rétiniennes :

Taille 

Valeur 

Grain 

Couleur 

Orientation 

Forme 

but du graphique :

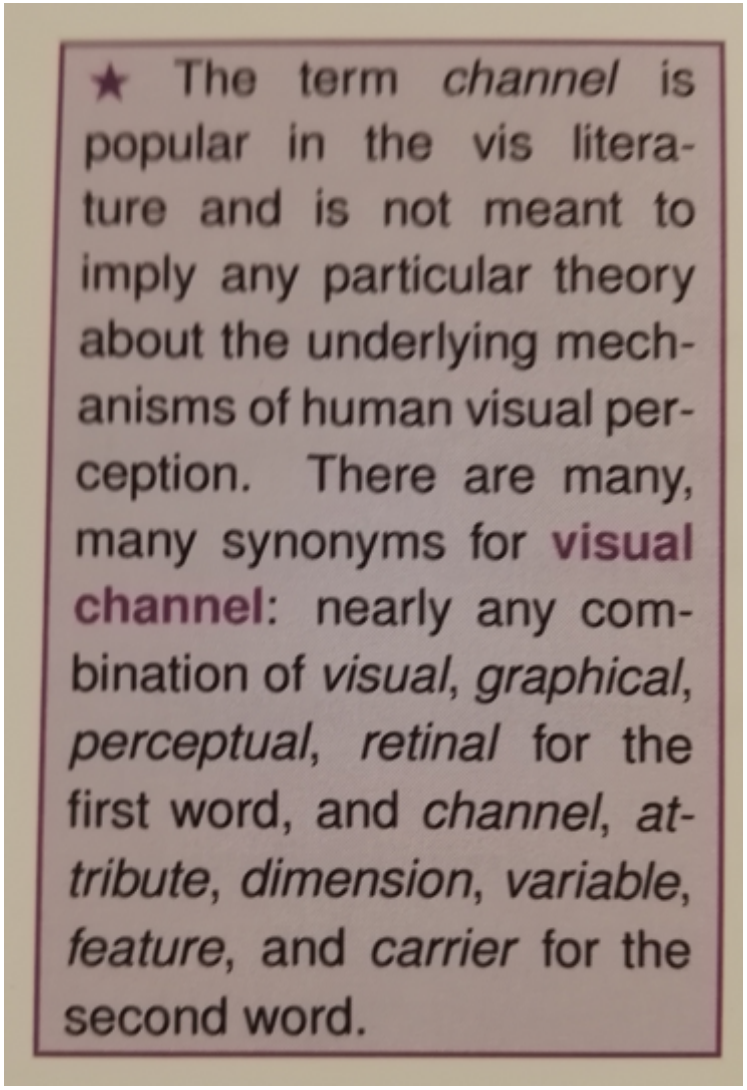
association de catégories → G C O F

selection d'une catégorie → T V G C

comparaison d'ordres → T V G

comparaison de quantités → T

problème de terminologie...



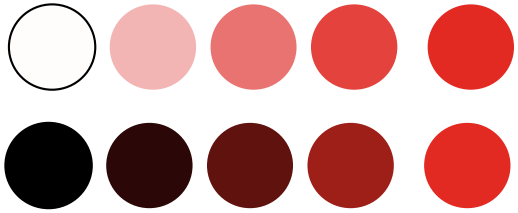
★ The term *channel* is popular in the vis literature and is not meant to imply any particular theory about the underlying mechanisms of human visual perception. There are many, many synonyms for **visual channel**: nearly any combination of *visual*, *graphical*, *perceptual*, *retinal* for the first word, and *channel*, *attribute*, *dimension*, *variable*, *feature*, and *carrier* for the second word.

[Munzner]

Attributs "modernes"

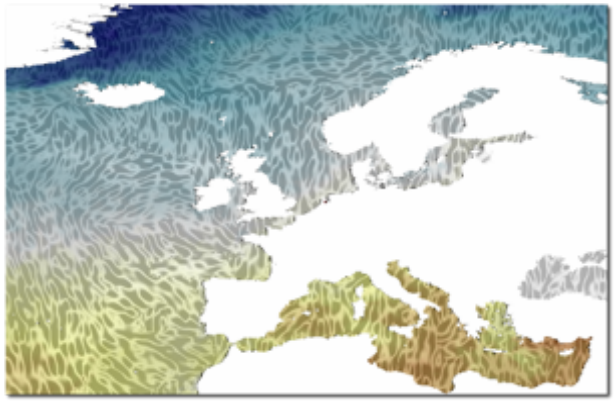
Saturation

Luminosité



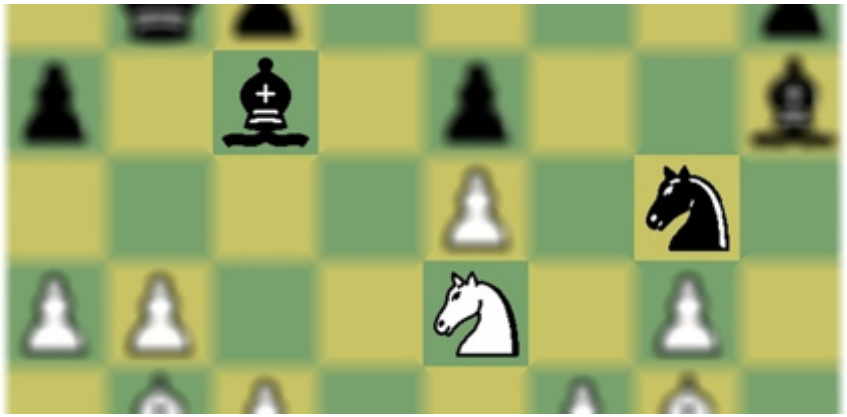
+ Transparence

Champs texturés



(Klebnikov et al, 2012)

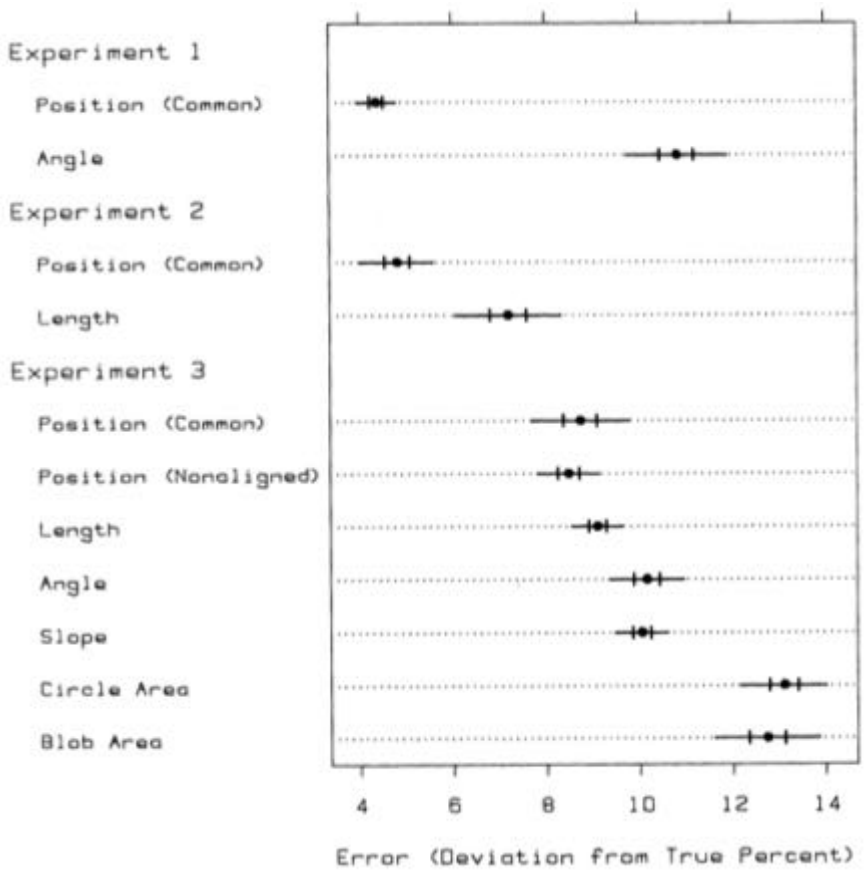
Flou

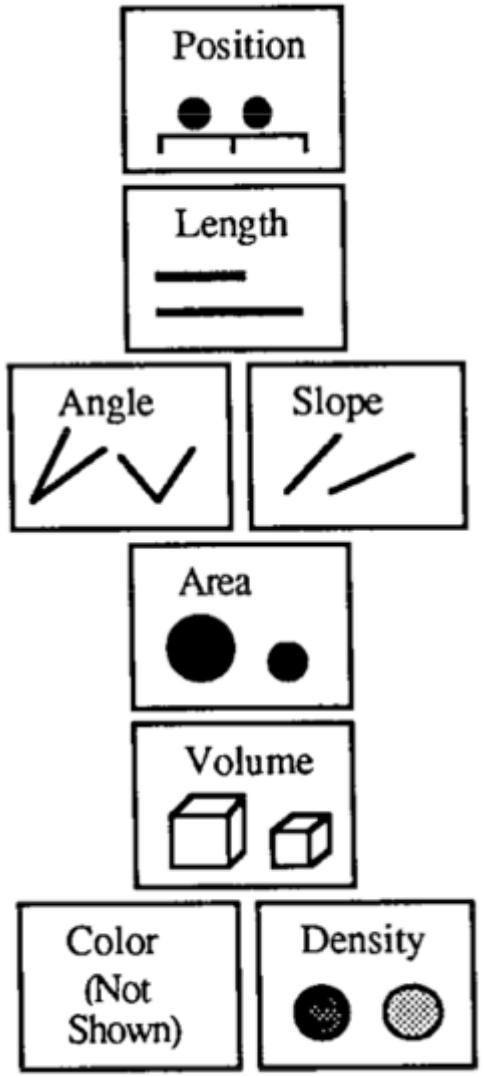


(Kosara et al., 2002)

+ clignotement + animation en général

Expériences de Cleveland et McGill (Science, n° 4716, 8/1985)





J. Mackinlay, ACM Trans. on Graphics, 5(2), 1986

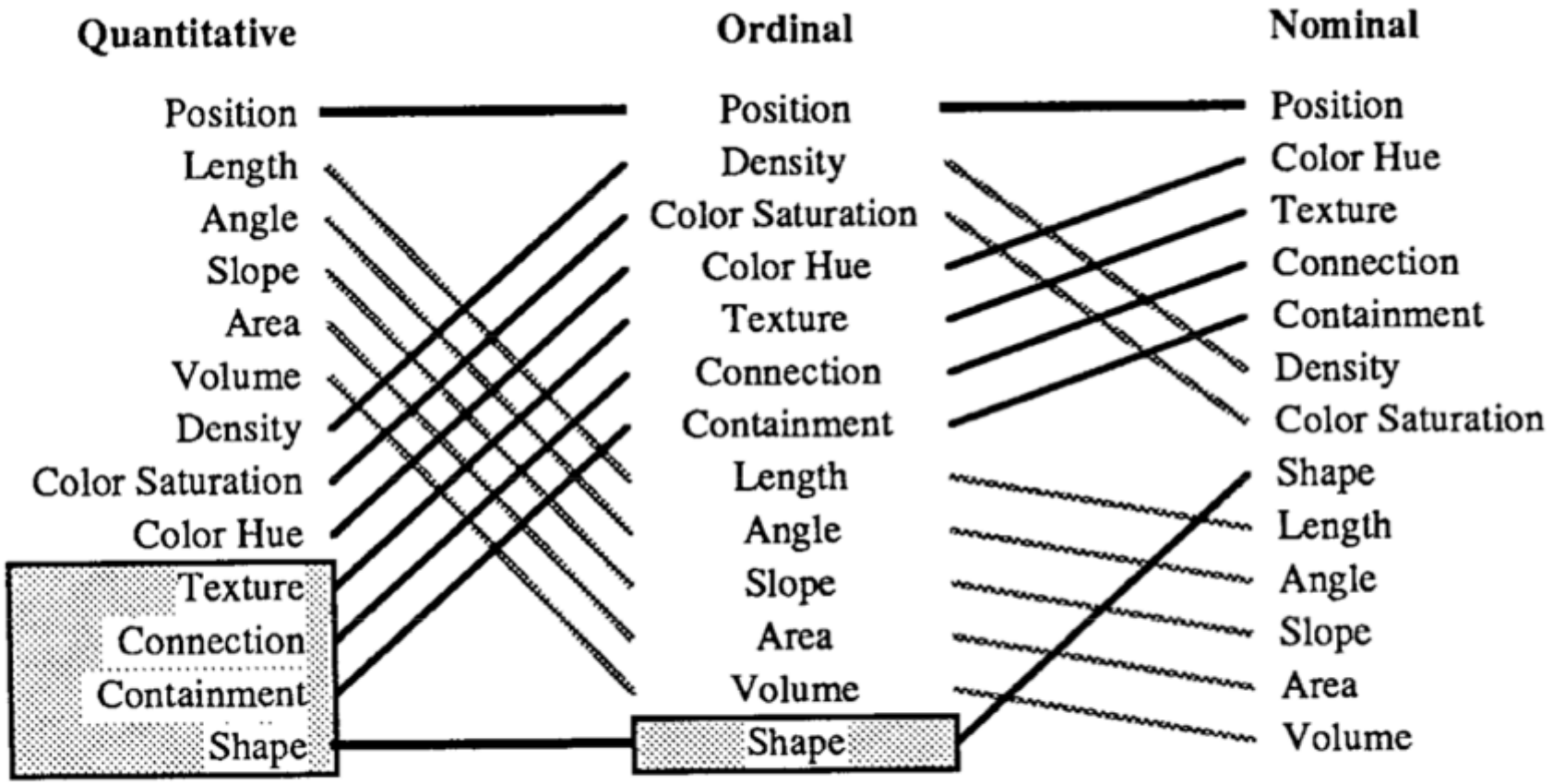
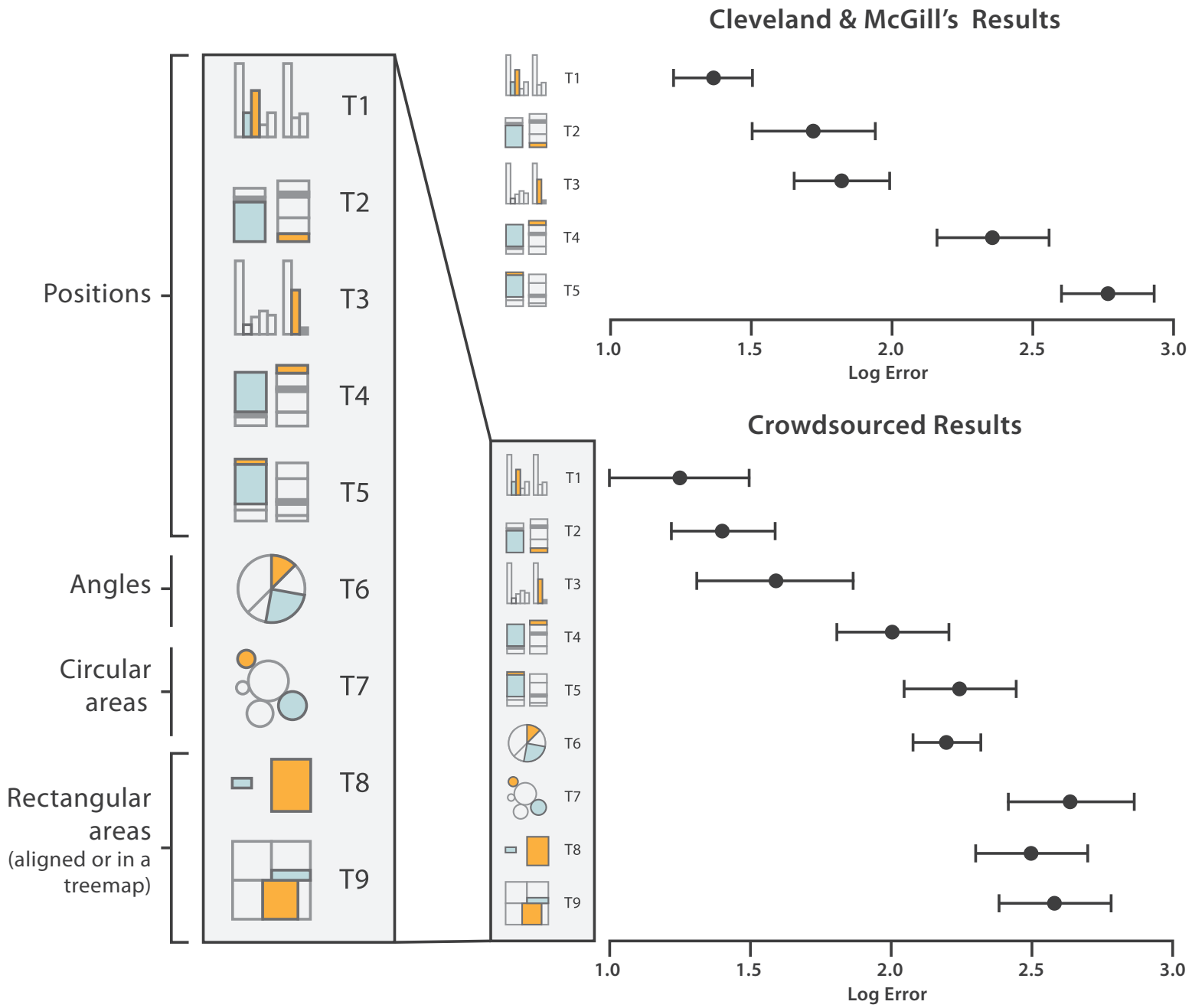
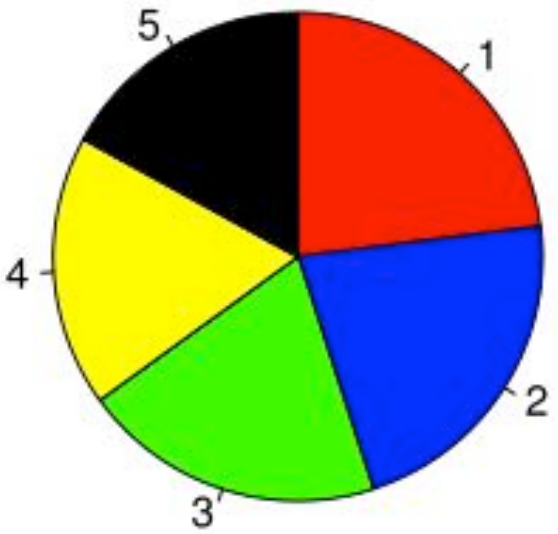


Fig. 15. Ranking of perceptual tasks. The tasks shown in the gray boxes are not relevant to these types of data.

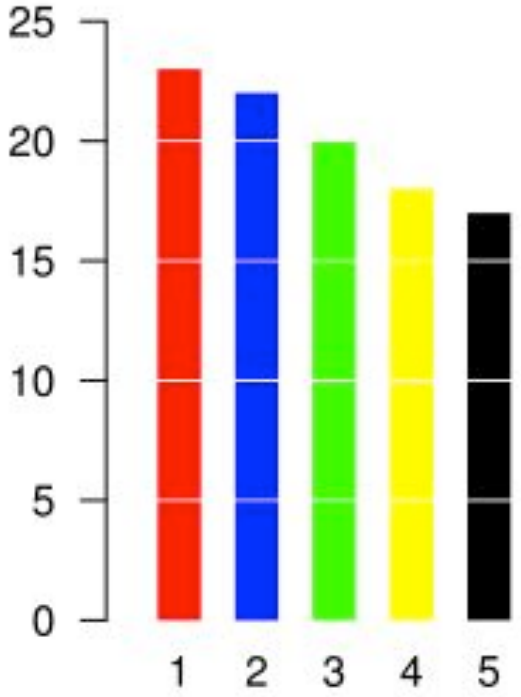
Experience de Heer & Bostock, 2010



Exemples avec les angles : camenberts (GB pie chart)

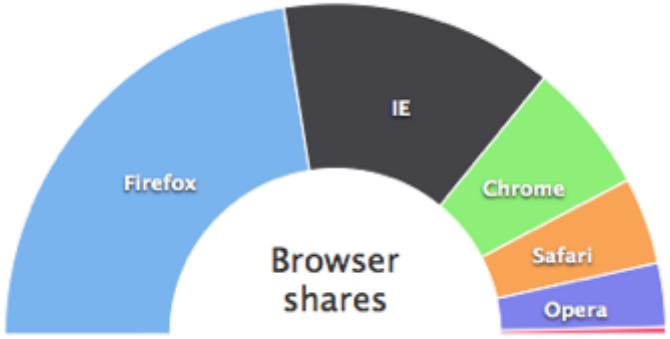


comparer avec :

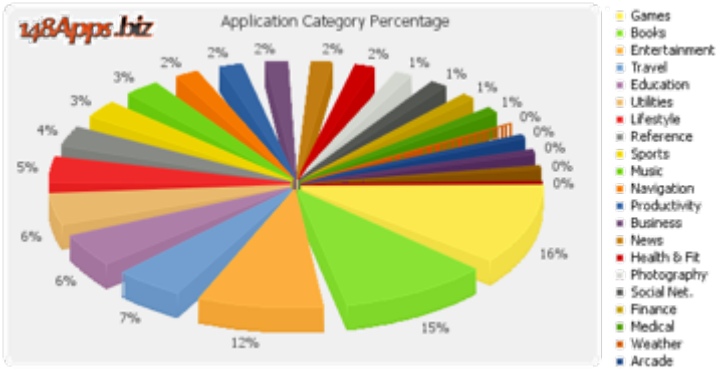


https://eagereyes.org/techniques/pie-charts

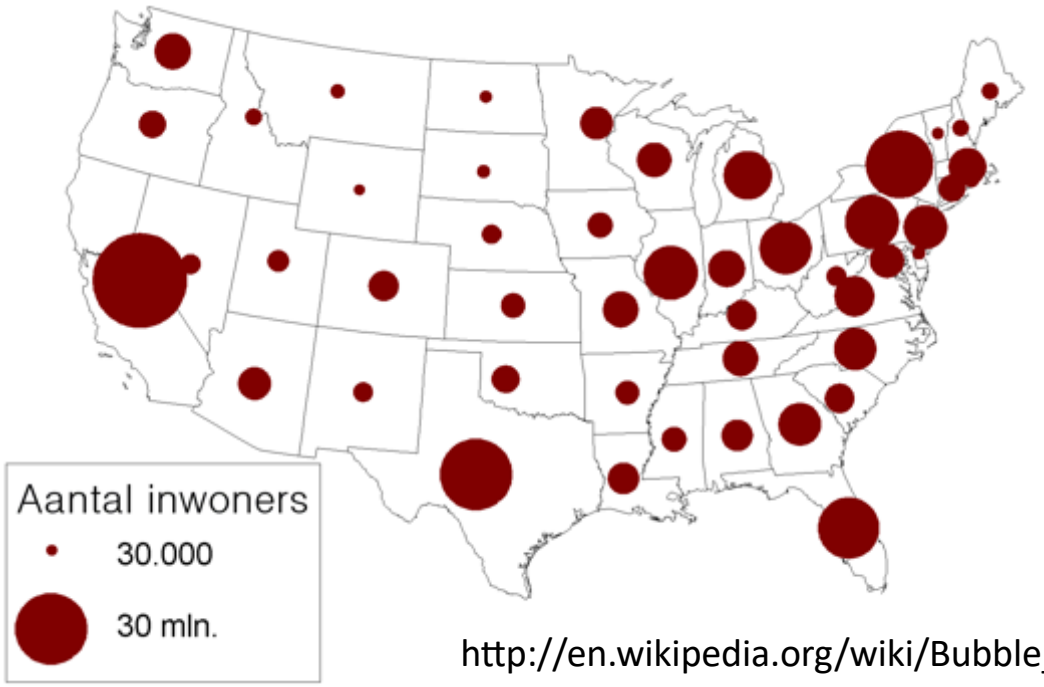
Variante "donut"



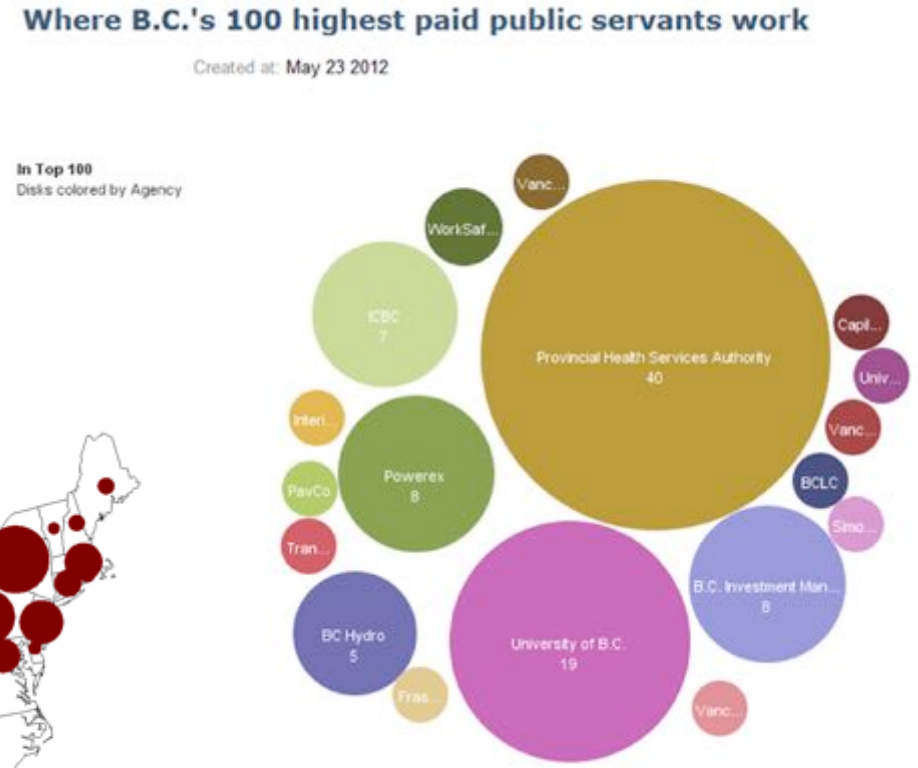
A éviter encore plus : la version 3D



Exemples
avec les surface :
bubble graphs



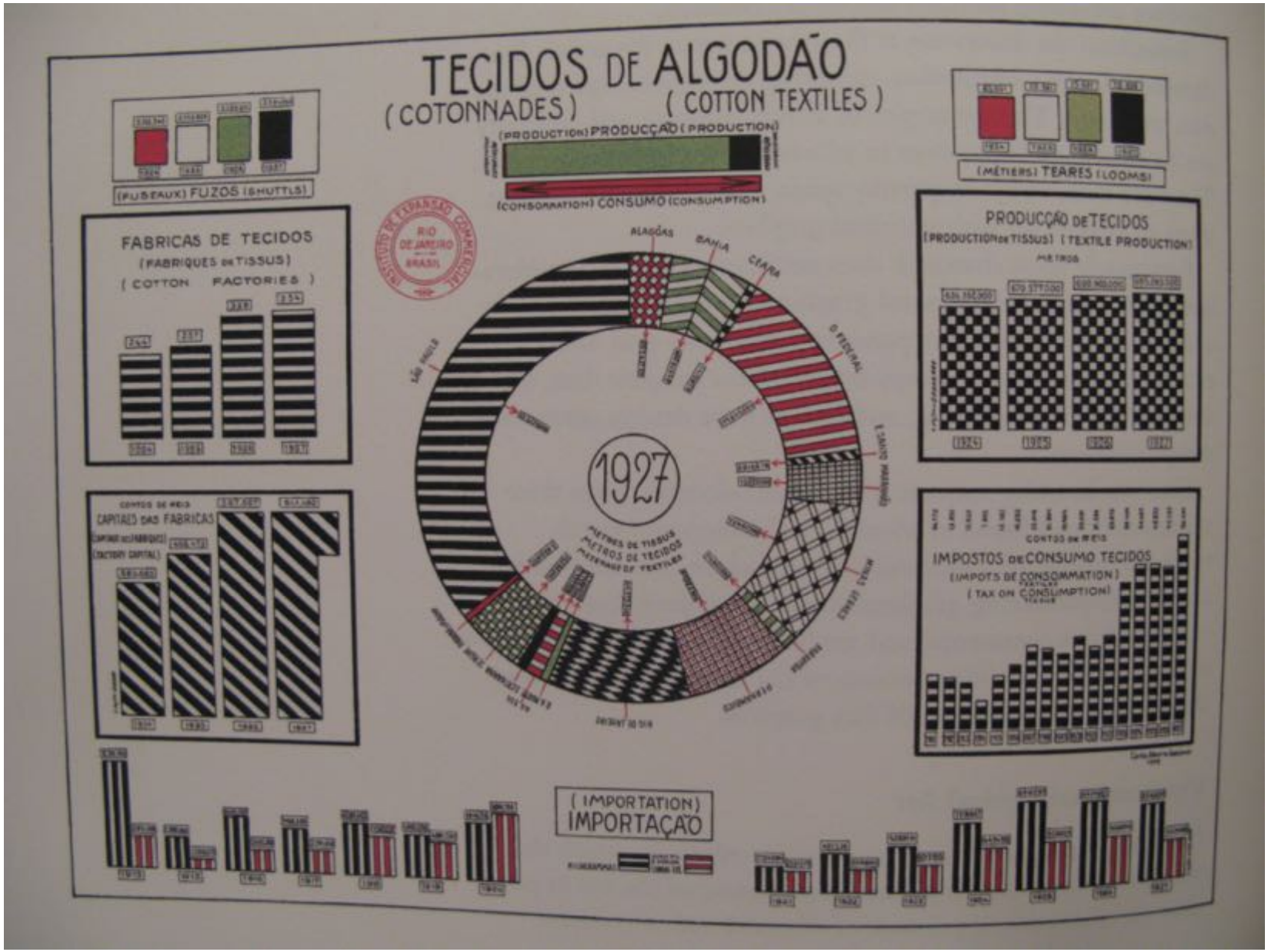
http://en.wikipedia.org/wiki/Bubble_chart



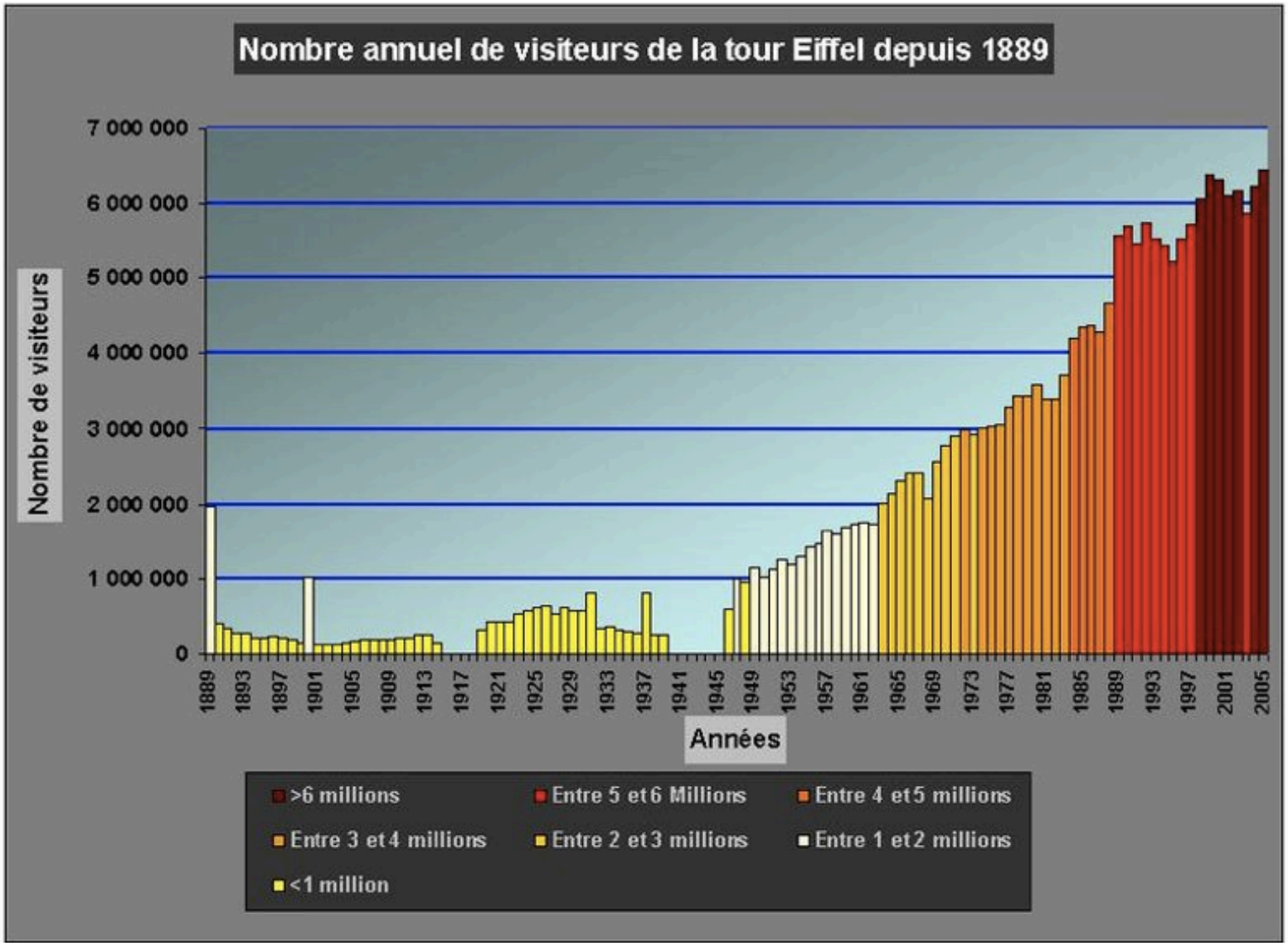
http://www.perceptualedge.com/blog/?p=1612

attention : surface ≠ rayon
quid des labels ?

Un schéma raté…. [Tufte, Visual p.108]

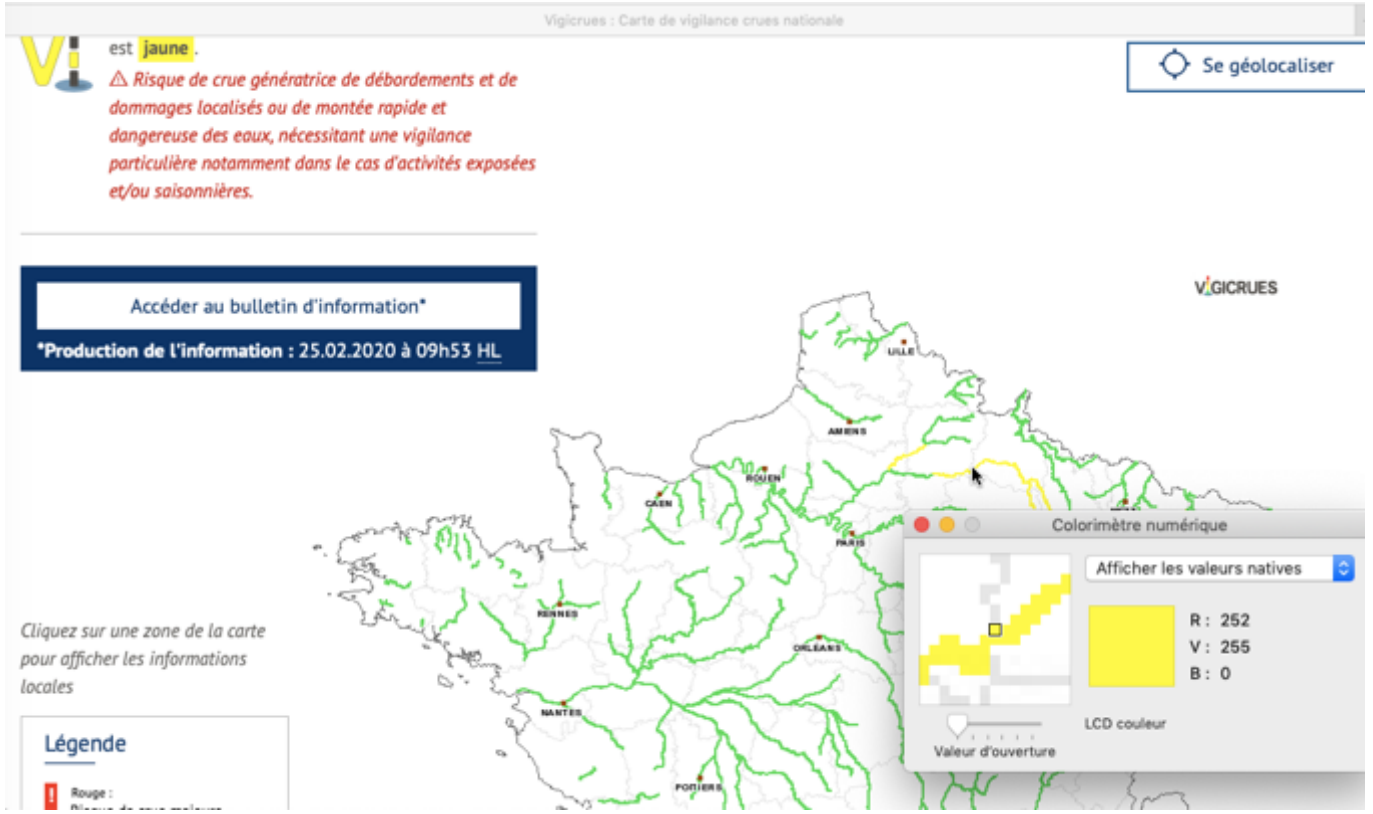


Un autre raté



http://fr.wikipedia.org/wiki/Portail:Tour_Eiffel

Mauvais codage : exemple du site Vigicrue

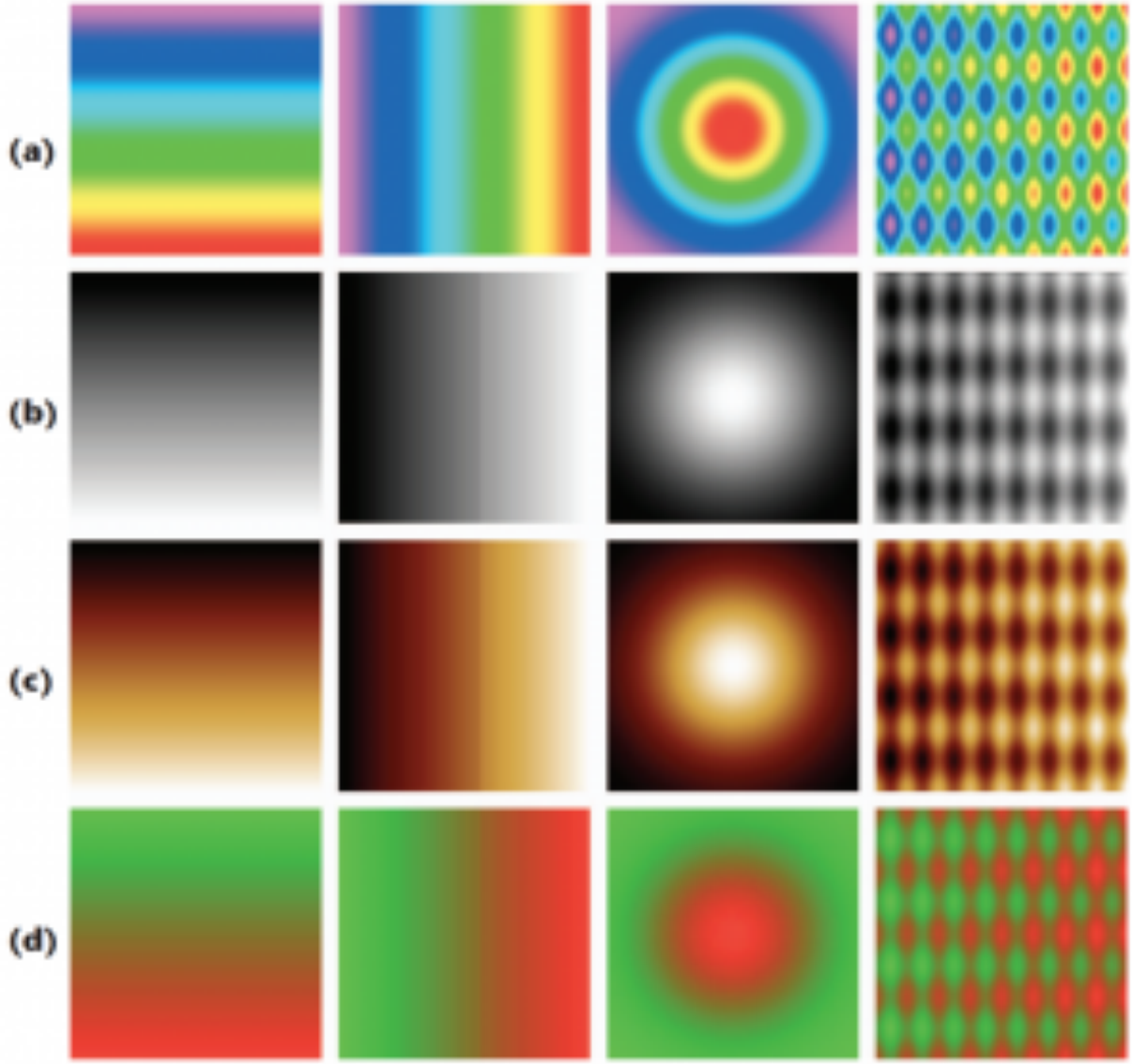


Le site utilise une classification classique rouge/orange/jaune/vert

Le jaune est trop primaire et mal lisible sur le fond blanc
(qui "code" le "non-rivière" sur la carte)

La couleur pour le quantitatif ?
ex. des cartes en "fausses couleur"

[Ware]



spectre visible
"rainbow"

valeur
"greyscale"

valeur
sur teinte

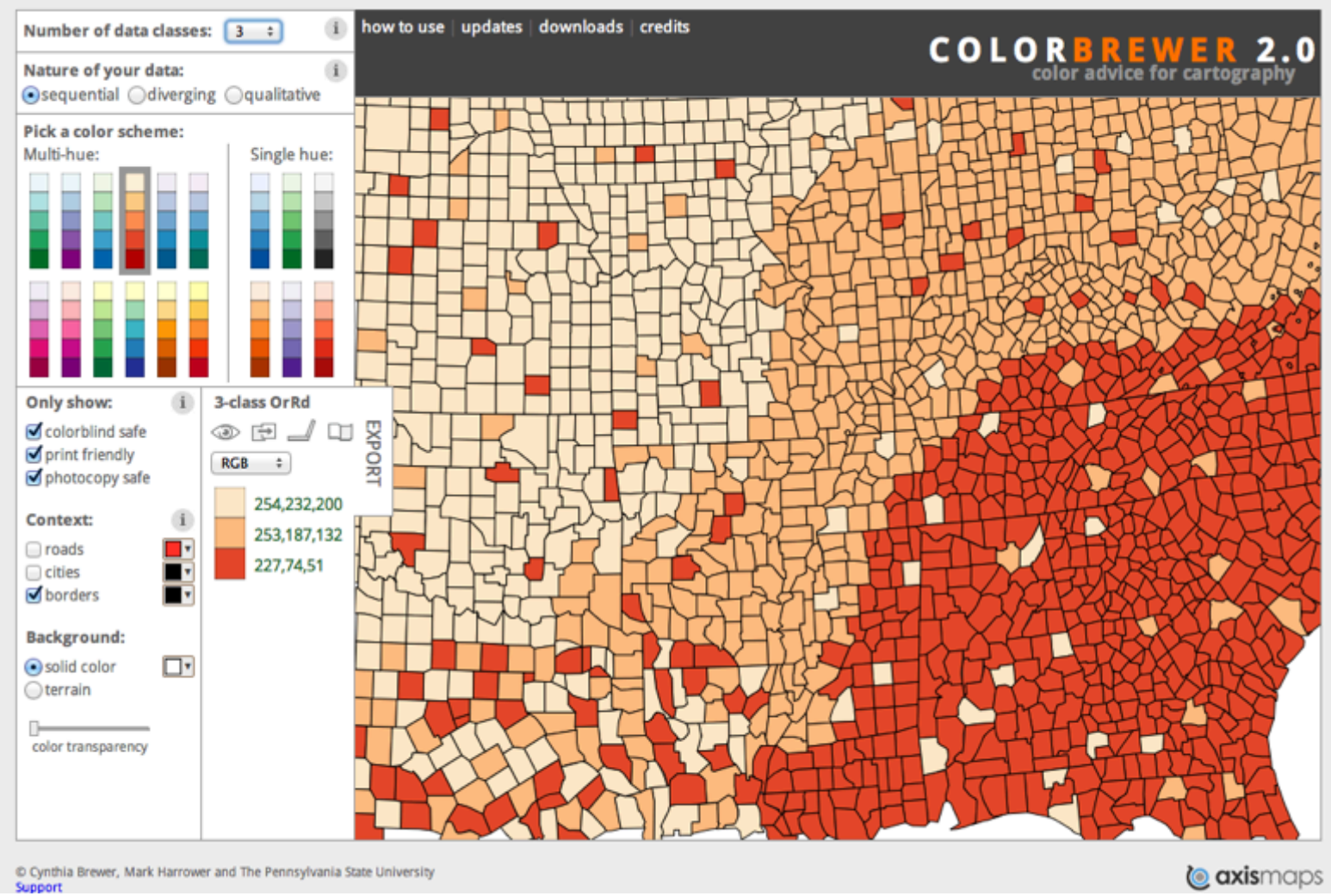
bidirectionel
rouge-vert

Exemple de Matlab

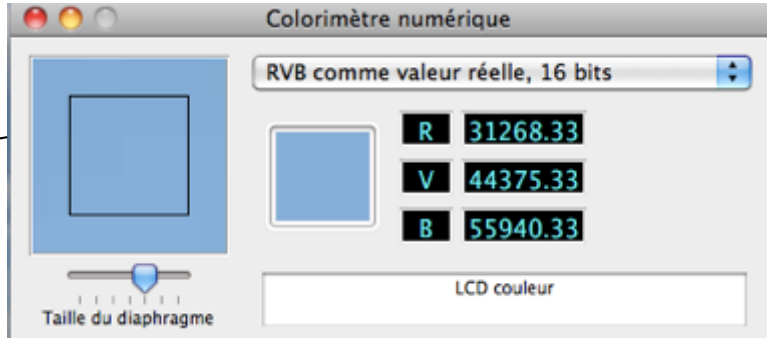
Colormap Name	Color Scale
parula	
jet	
hsv	
hot	
cool	
spring	
summer	
autumn	
winter	
gray	
bone	
copper	
pink	

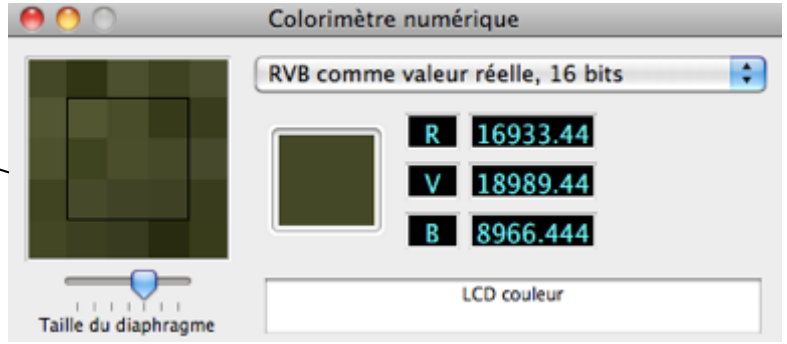
Eviter : jet et hsv

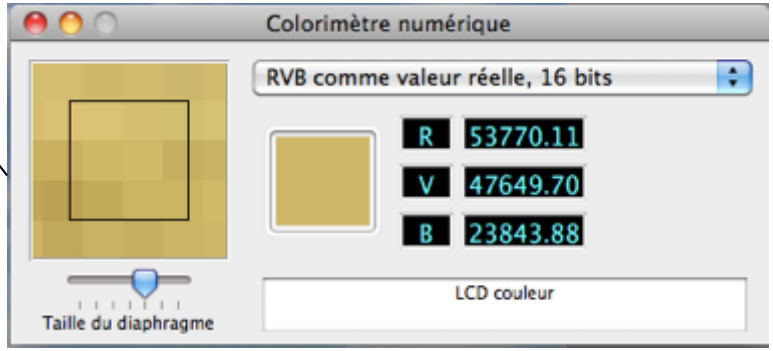
Bonne appli en ligne http://colorbrewer2.org/



Bon conseil de Tufte : choisir des couleurs de la nature



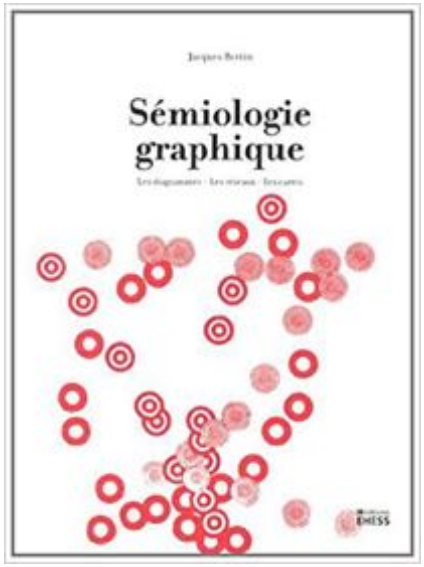




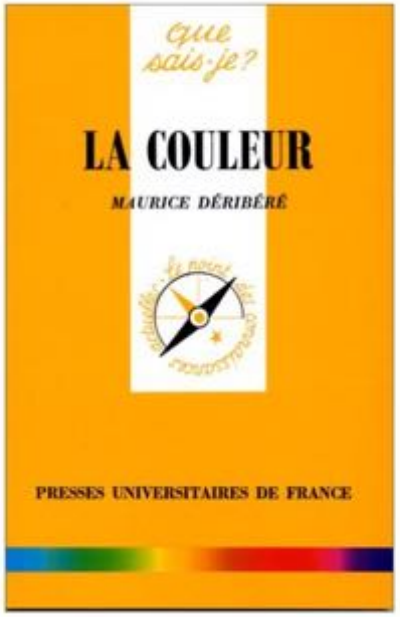
avec
une
« pipette »

Colorimètre numérique.app

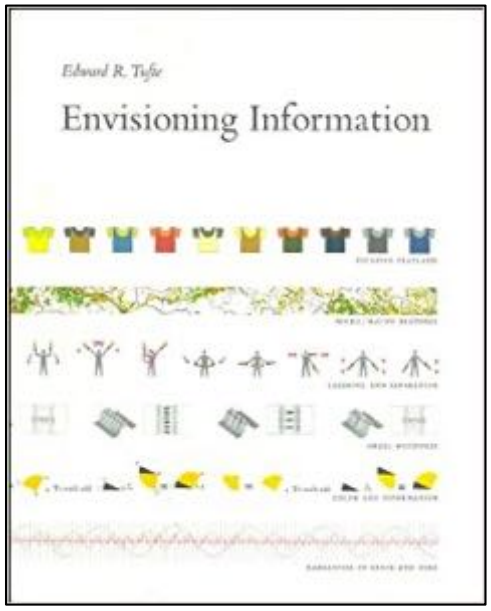
Ouvrages cités



[Bertin]

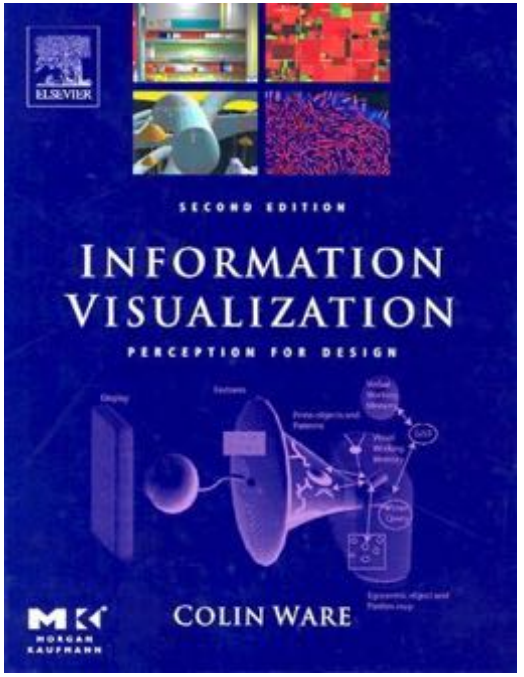


[Déribéré]



[Tufte]

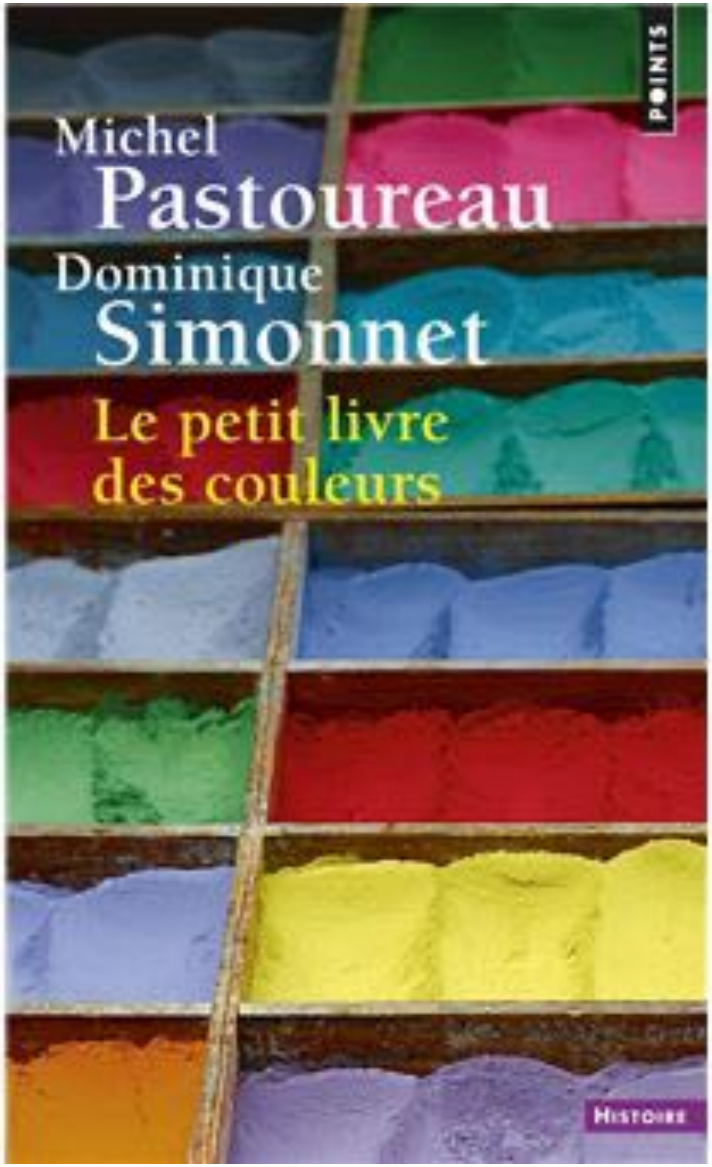
http://www.edwardtufte.com/tufte/



[Ware]

Culture de la couleur, "psychologie" et marketing

https://www.abondance.com/20170609-18098-infographie-psychologie-couleurs-taux-de-conversion.html


POINTS
Michel
Pastoureau
Dominique
Simonnet
Le petit livre
des couleurs
HISTOIRE