

Towards a Flexible, Reusable Model for Predicting Eye Movements During Visual Search of Computer Screens:

Investigating the Effects of Semantic and Perceptual Grouping

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Motivations & Research Questions

★How does grouping layout elements affect visual search?

- Many guidelines for the design of web pages (e.g. National Cancer Institute, 2002) and application interfaces (e.g. Mullet & Sano, 1995) exist without direct or sufficient empirical support.
 - Mullet & Sano (1995) recommend using background color to visually organize layouts based on Gestalt psychology principle of common region.
 - Communication researchers (Moore & Fitz, 1993; Smith, 2005) have qualitatively analyzed the impact of using Gestalt principles to improve visual layouts, but little if any quantitative research has been conducted on how Gestalt principles affect people's visual search of layouts.

★How do the gestalt principles of proximity and common region affect visual search?

- A fair amount of research has been conducted on how the semantic content of items affects visual search.
 - E.g. Brumby and Howes (in press) investigated when people tend to *select* or *revisit* menu items based on the semantic content.
 - However, little if any research has investigated when people “filter” un-visited items based on the semantic content.

★How does the semantic grouping of items affect visual search?

Motivations & Research Questions

craigslist: eugene classifieds for jobs, apartments, personals, for sale, services, community,

craigslist

[post to classifieds](#)

[my account](#)

[help, faq, abuse, legal](#)

[search craigslist](#)

for sale >

event calendar (35)

| | | | | | | |
|----|----|----|----|----|----|----|
| S | M | T | W | T | F | S |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |

[avoid scams & fraud](#)

[job boards compared](#)

[lawsuit dismissed](#)

[defend net neutrality](#)

[Katrina Relief](#)

[best-of-craigslist](#)

[craigslist factsheet](#)

[craigslist movie & dvd](#)

[craigslist T-shirts](#)

[craigslist foundation](#)

system status

[terms of use](#) [privacy](#)

[about us](#) [help](#)

eugene^w

community (1728)

[activities](#) [lost+found](#)

[artists](#) [musicians](#)

[childcare](#) [local news](#)

[general](#) [politics](#)

[groups](#) [rideshare](#)

[pets](#) [volunteers](#)

[events](#) [classes](#)

personals (4285)

[strictly platonic](#)

[women seek women](#)

[women seeking men](#)

[men seeking women](#)

[men seeking men](#)

[misc romance](#)

[casual encounters](#)

[missed connections](#)

[rants and raves](#)

discussion forums

| | | |
|---------|---------|----------|
| 1099 | gifts | pets |
| apple | haiku | philos |
| arts | health | politic |
| atheist | help | psych |
| autos | history | queer |
| beauty | housing | recover |
| bikes | jobs | religion |
| celebs | jokes | rofo |
| comp | kink | science |
| crafts | l.t.r. | shop |
| diet | legal | spirit |
| divorce | linux | sports |
| dying | loc pol | t.v. |
| eco | m4m | tax |
| educ | money | testing |
| etiquet | motocy | transg |
| feedbk | music | travel |
| film | npo | vegan |

housing (2056)

[apts / housing](#)

[rooms / shared](#)

[sublets / temporary](#)

[housing wanted](#)

[housing swap](#)

[vacation rentals](#)

[parking / storage](#)

[office / commercial](#)

[real estate for sale](#)

for sale (17928)

| | |
|-----------|--------------|
| barter | auto parts |
| bikes | baby+kids |
| boats | cars+trucks |
| books | cds/dvd/vhs |
| free | clothes+acc |
| furniture | collectibles |
| general | computer |
| jewelry | electronics |
| rvs | garage sale |
| sporting | household |
| tickets | motorcycles |
| tools | music instr |
| wanted | |

services (1390)

| | |
|-----------|---------------|
| computer | automotive |
| creative | household |
| erotic | labor/move |
| event | skill'd trade |
| financial | real estate |
| legal | sm biz ads |
| lessons | therapeutic |

jobs (1012)

[accounting+finance](#)

[admin / office](#)

[arch / engineering](#)

[art / media / design](#)

[biotech / science](#)

[business / mgmt](#)

[customer service](#)

[education](#)

[government](#)

[human resources](#)

[internet engineers](#)

[legal / paralegal](#)

[marketing / pr / ad](#)

[medical / health](#)

[nonprofit sector](#)

[retail / food / hosp](#)

[sales / biz dev](#)

[skilled trade / craft](#)

[software / qa / dba](#)

[systems / network](#)

[technical support](#)

[tv / film / video](#)

[web / info design](#)

[writing / editing](#)

[\[ETC\] \[part time\]](#)

gigs (99)

| | |
|----------|---------|
| computer | event |
| creative | labor |
| crew | writing |
| domestic | talent |
| | adult |

resumes (83)

us states

alabama
alaska
arizona
arkansas
california
colorado
connecticut
delaware
dc
florida
georgia
guam
hawaii
idaho
illinois
indiana
iowa
kansas
kentucky
louisiana
maine
maryland
mass
michigan
minnesota
mississippi
missouri
montana
nebraska
nevada
n hampshire
new jersey
new mexico
new york
n carolina
north dakota
ohio
oklahoma
oregon
pennsylvania
puerto rico
rhode island
s carolina
south dakota

ca provs

alberta
brit columbia
manitoba
n brunswick
newf & lab
nova scotia
ontario
pei
quebec
saskatchwn

ca cities

montreal
toronto
vancouver
more ..

us cities

atlanta
austin
boston
chicago
dallas
denver
houston
las vegas
los angeles
miami
minneapolis
new york
orange co
philadelphia
phoenix
portland
raleigh
sacramento
san diego
seattle
sf bayarea
wash dc

int'l cities

amsterdam
bangalore
berlin
buenosaires

countries

argentina
australia
austria
bangladesh
belgium
brazil
canada
caribbean
chile
china
colombia
costa rica
czech repub
denmark
egypt
finland
france
germany
great britain
greece
hungary
india
indonesia
ireland
israel
italy
japan
korea
lebanon
malaysia
mexico
micronesia
netherlands
new zealand
norway
pakistan
panama
peru
philippines
poland
portugal
russia
singapore
south africa

Experimental Design

Semantically-
Cohesive
Groups

| | With Background Color | Without Background Color |
|-----------------------|-----------------------------|--------------------------------|
| Groups Labeled | X | X |
| Groups Not Labeled | X | X |

Random
Groups

| | With Background Color | Without Background Color |
|-----------------------|-----------------------------|--------------------------------|
| Groups Labeled | | |
| Groups Not Labeled | X | X |

Experimental Design: Semantic-Cohesive Groups, Labels & Background Color

jewelry

- anklet
- bracelet
- cufflink
- ring
- crown

cloth

- denim
- wool
- linen
- polyester
- cashmere

nuts

- cashew
- peanut
- almond
- walnut
- pistachio

building part

- basement
- attic
- bedroom
- backdoor
- balcony

homes

- shack
- house
- igloo
- dormitory
- trailer

farm animals

- sheep
- goat
- cow
- duck
- chicken

birds

- cardinal
- woodpecker
- bluebird
- hawk
- pigeon

extinct animals

- tyrannosaurus
- brontosaurus
- dinosaur
- dodo
- pterodactyl

Experimental Design: No Labels

- duck
- turkey
- lamb
- cow
- sheep

- gerbil
- opossum
- beaver
- gopher
- rat

- perch
- whitefish
- pike
- shark
- goldfish

- soprano
- mezzo
- contralto
- baritone
- tenor

- dinosaur
- tyrannosaurus
- neanderthal
- stegosaur
- dodo

- coal
- solar
- hydro
- gas
- wind

- potassium
- oxygen
- helium
- nitrogen
- sulfur

- pearl
- ruby
- emerald
- amethyst
- jade

Experimental Design: Random Groups

- cashmere
- dresser
- heart
- mansion
- pear

- celery
- urology
- thesaurus
- banker
- island

- engineer
- officer
- gloss
- steel
- canteen

- book
- coffee
- sheep
- lightning
- earring

- sprite
- sucker
- pen
- eyelashes
- country

- psychiatrist
- toe
- pork
- queen
- taffy

- tire
- orange
- crockpot
- corn
- oboe

- mosque
- chest
- gerbil
- pita
- juice

Experimental Design: No Background Color

- stream
- island
- mentor
- lithium
- chair

- pancreas
- sapphire
- sparrow
- duchess
- blowfish

- shirt
- peach
- champagne
- shack
- pepsi

- elm
- eraser
- potato
- alternative
- monastery

- train
- cabinet
- pineapple
- trailmix
- tugboat

- peas
- carburetor
- hamster
- helium
- silk

- handlebars
- pine
- highlighter
- lord
- jacket

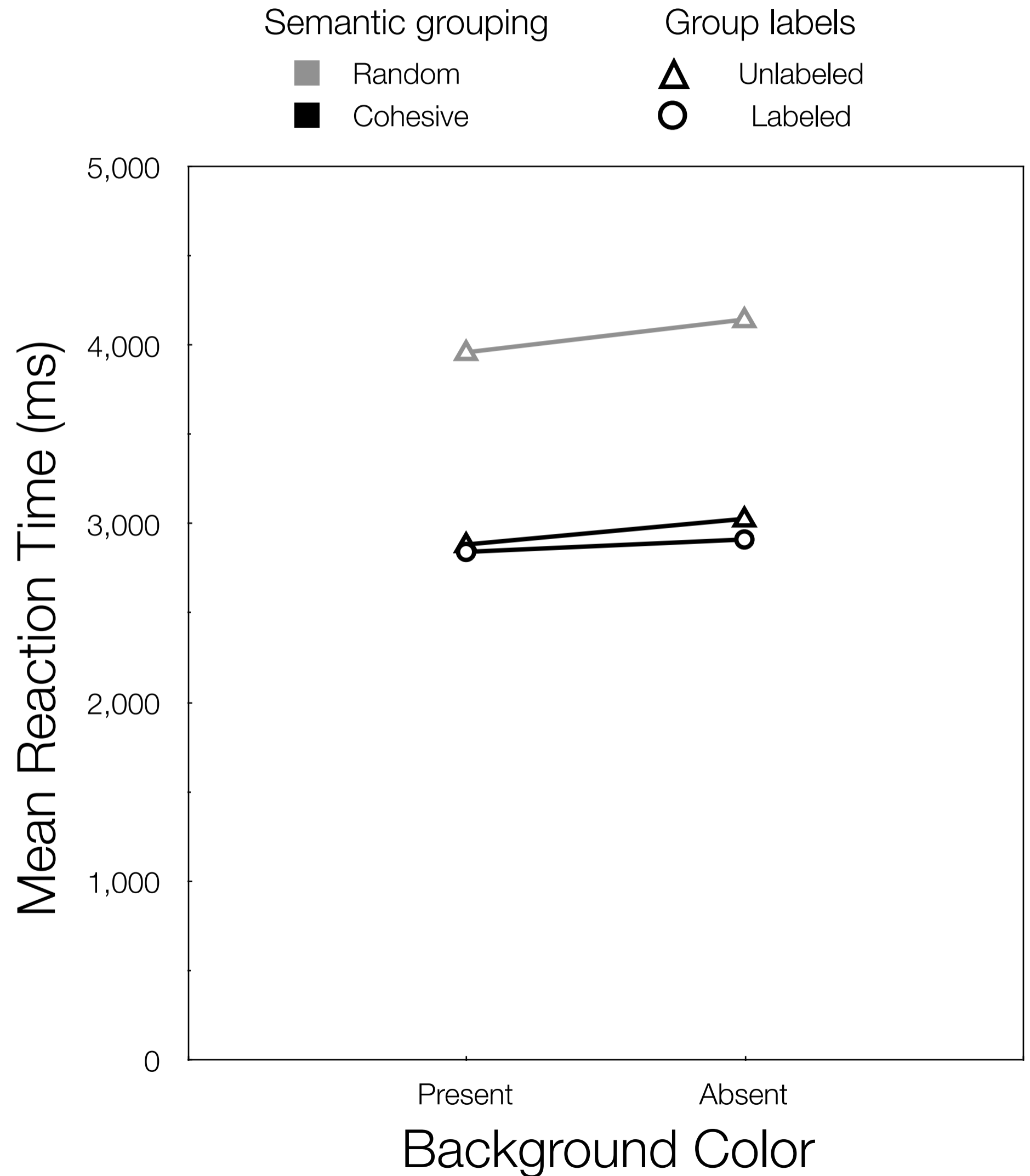
- obstetrics
- syringe
- mountain
- barge
- tweezer

Hypotheses

- People use grouping by background color to guide visual search when properly motivated.
- People are more likely to saccade to nearby groups.
- Semantic-cohesion increases the likelihood of people exhaustively searching fewer groups.

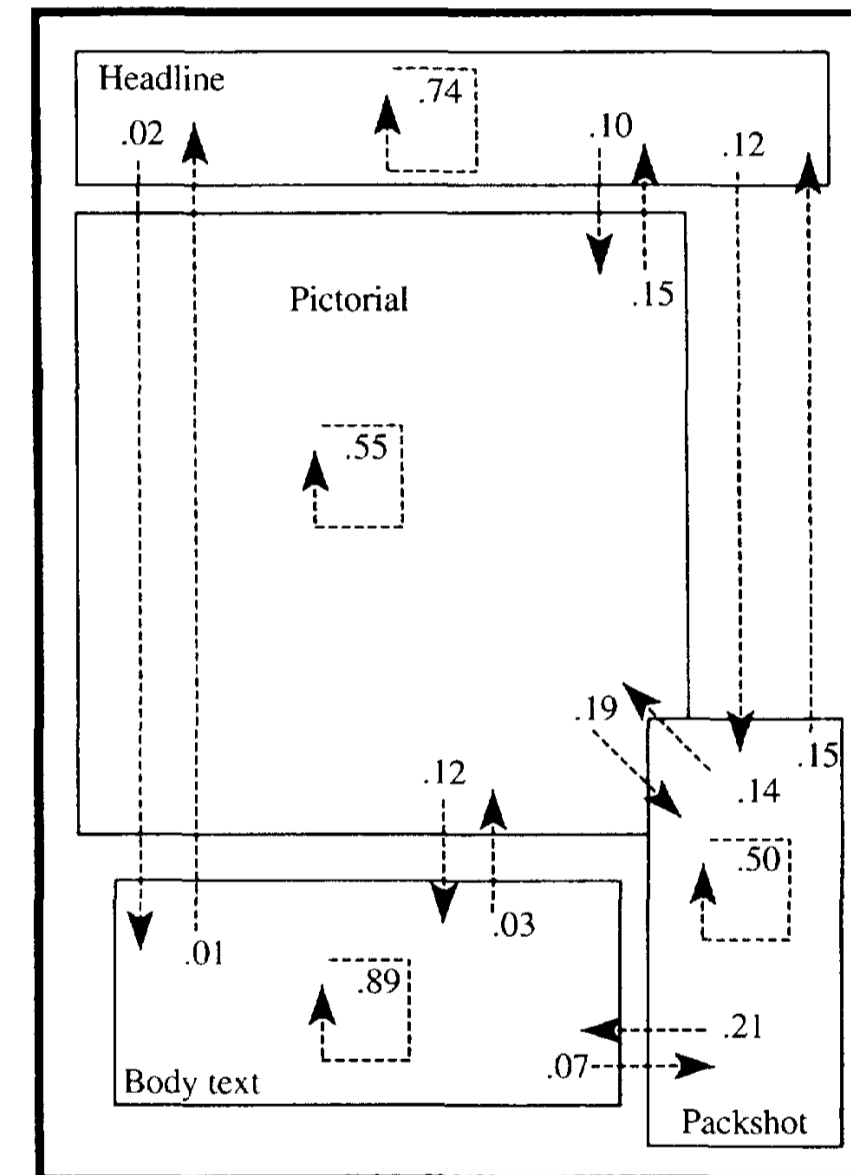
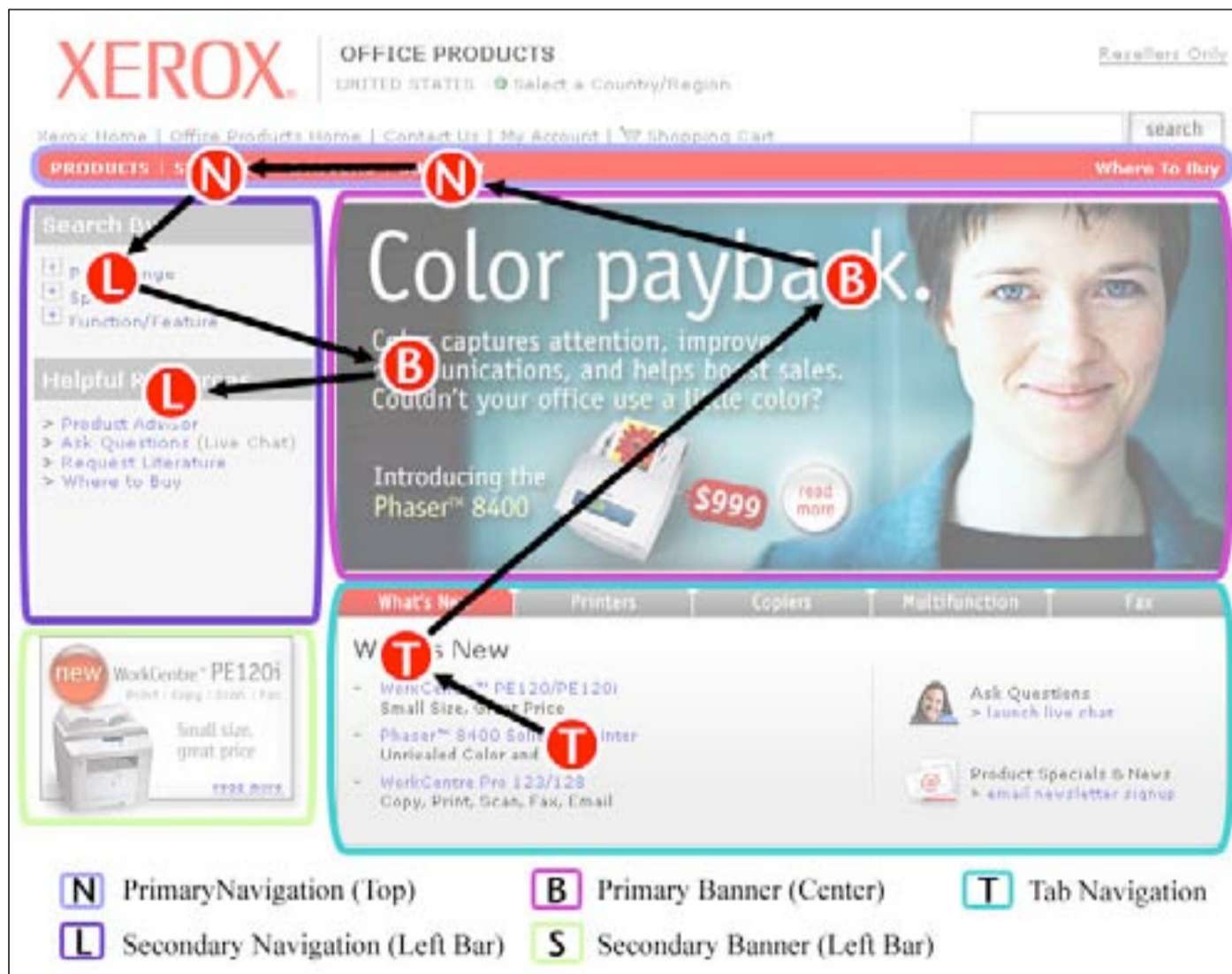
Results

- Search is clearly faster when groups are semantically-cohesive
- Search is significantly faster when groups are labeled, but only marginally so.
- Search is not (significantly) aided by the background color.
 - However, the mean reaction time is marginally lower when the background color is present.



Eye movement analysis

- When investigating visual search, look at the eye movements.
- Aggregate eye movement data (e.g. # of fixations) is interesting, but only to a certain point.
- Recent eye movement metrics of importance are scanpaths.



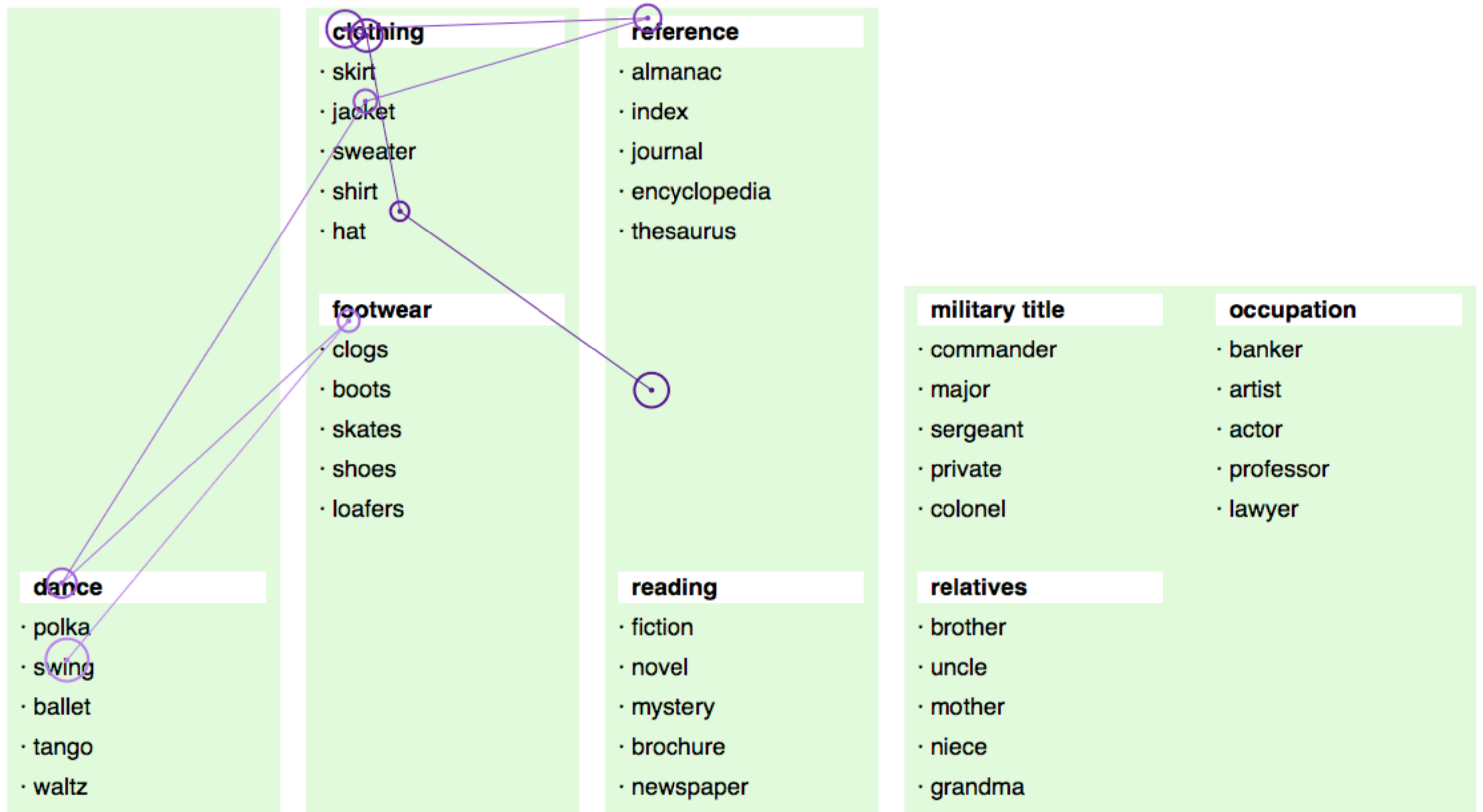
a
 S1: ...BNBLPLOLOLPBxB
 S2: SLLPLOLSPOLPOSBXPS...

b
 LPLOL--OLP--BX
 ||||| ||| ||
 LPLOLSPOLPOSBX

Image from Pieters, Rosbergen & Wedel (1999)

Images from West, Haake, Roznaski & Karn (2006)

Eye movement analysis



Eye movement analysis

- maple
- birch
- willow
- oak
- spruce

- brook
- ocean
- river
- creek
- stream

- mast
- rudder
- bow
- hull
- oar

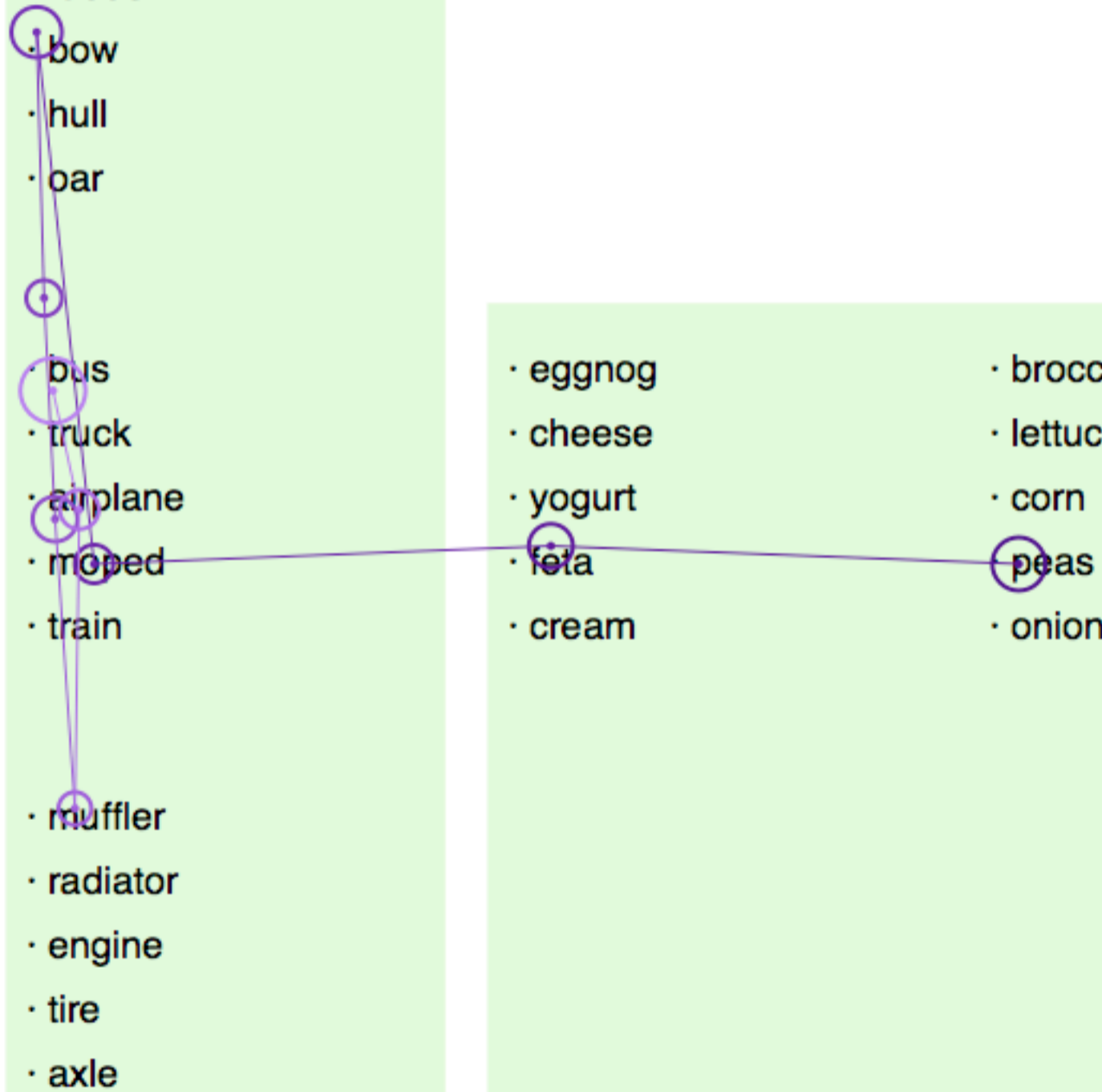
- toaster
- mixer
- microwave
- timer
- crockpot

- bus
- truck
- airplane
- moped
- train

- muffler
- radiator
- engine
- tire
- axle

- eggnog
- cheese
- yogurt
- feta
- cream

- broccoli
- lettuce
- corn
- peas
- onion



Questions for you

- How can string alignment be used if the meaning of the string elements vary between strings?
- How can substitution costs be calculated?
- Are there variations of Markov models that would be more useful for this analysis?
- What are the most useful pattern finding methods to use?

