Ambient/focal visual fixations dichotomy in natural scene perception

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Sous l’encadrement industriel de Christel Chamaret
Plan

1. Introduction
   1. Perception
   2. Attention
   3. Problematic
2. Experiment 1: Spatial deployment of ambient and focal fixations
3. Experiment 2: Focal fixations and object processing
4. Experiment 3: Ambient fixations and global scene processing
5. Conclusion
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A dissociation in the visual system

Local
- Late
- Fine
- High Frequencies
- Foveal vision
- Recognition / Reading
- Semantic
- Conscious

Global (Navon & al. 77)
- Early
- Coarse (Parker & al. 92)
- Low Frequencies (Oliva & al. 94)
- Peripheral vision
- Localization / spatial
- Ecological / motor / action
- Unconscious

Posterior Parietal Cortex

Dorsal (where) pathway
- V1, V2
- & V3

Infero Temporal Cortex

Ventral (what) pathway
1. **Introduction**
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Are there 2 kinds of overt attention?

The scanpath

- Fixation Duration (FD)
- Saccade Amplitude (SA) (next or previous)
- Time Viewing / fixation number

Time Viewing: A first index for global-to-local strategy

In different specific instruction tasks (Yarbus 67, Tatler & al. 08) and contexts (Buswell (35), Unema & al. (05), Pannasch & al. (08) and Over & al. (09))
Saccade Amplitude as a function of Fixation Duration

**Ambient**
Large and fast scanning to perceive the scene globally

**Focal**
Long and local scanning to process deeply specific regions of the scene

*Velichkovsky & al. (05)*

*Unema & al. (05)*

*Tatler & al. (08)*

*Ho phuoc & al. (12)*

→ EEG gamma bands (40-70 Hz) distinguish two visual processes *Fischer & al. (11)*
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Are there many kinds of fixations?

What is the impact on the understanding of attention?

Have they different functions?

What is the impact on modeling?
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5. **Conclusion**
Experiment 1: Ambient and focal fixations

- **Goal**
  - Can we systematically observe ambient/focal relationship?

- **Protocol**
  - Eye-tracking (4 sec. recording)
  - Free Viewing (36 subjects)
  - Stimuli: 4 natural scene categories (Torralba & Oliva 2001)

Coast

Open Country

Mountain

Street
Results

Fixation Duration (FD)

Saccade Amplitude (SA)

- Next SA
- Previous SA

Fixation Duration (ms)

Time Viewing (ms)
To identify ambient and focal fixations

- **Method**: How to separate a priori no distinct data?

Using **K–means algorithm**

- Centroid: Local optimum
- No parametric data clustering

- **Results**
  - *Saccade Amplitude* (SA) separates the fixations
  - *Fixation Duration* (FD) is useless

2 clusters

- **Small SA Focal fixations** 70% (2.5°)
- **Great SA Ambient fixations** 30% (10.5°)
Spatial deployment assessment

Goal
- To test relationship between ambient/focal and low/high level dissociations (Pannasch & al. 08)
  Comparison with bottom-up visual attention models

Method: Ambient/focal maps comparison (AUC)

Results

<table>
<thead>
<tr>
<th>Method</th>
<th>AUC Value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient</td>
<td>0.76</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Focal</td>
<td>0.84</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Focal Fixations are more:
- Sensitive to the saliency (Tatler & al. 2006)
- Centred
Time course of ambient and focal fixations

- **Focal** occurs earlier than ambient
- Around 1 second

Opposite to the *global-to-local* classical view (Pannasch & al. 2008)

**Ambient/focal** dichotomy is different to the *bottom-up/top-down* opposition
Summary experiment 1

- Focal and ambient fixations show different phases
- Focal and ambient fixations have different occurrence probability
- Focal and ambient fixations show different spatial deployment

Hypothesis

Investigation: The functional role of ambient and focal fixations

- Experiment 2: Focal and object processing relationship
- Experiment 3: Ambient fixations and global scene processing relationship
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## Experiment 2: Focal & objects

### Goal
- Investigation of the relationship between focal fixations and object processing

### Protocole
- 120 images * 2 conditions (A & B)
- 4 categories: Street, Coast, Mountain & OpenCountry
- 47 subjects (mean age 38.5, STD = 9.5)

### K-means stability

<table>
<thead>
<tr>
<th></th>
<th>SA</th>
<th>First Experiment</th>
<th>With object (A)</th>
<th>Without object (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Focal centroid</strong></td>
<td>2.5°</td>
<td>3°</td>
<td>3.5°</td>
<td>SA are relatively stable</td>
</tr>
<tr>
<td><strong>Ambient centroid</strong></td>
<td>10.5°</td>
<td>15°</td>
<td>12.2°</td>
<td>***</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>FD</th>
<th>First Experiment</th>
<th>With object (A)</th>
<th>Without object (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Focal centroid</strong></td>
<td>169 ms</td>
<td>ns</td>
<td>154 ms</td>
<td>FD are not stable</td>
</tr>
<tr>
<td><strong>Ambient centroid</strong></td>
<td>170 ms</td>
<td>195 ms</td>
<td>244 ms</td>
<td>***</td>
</tr>
</tbody>
</table>

*Opposite to the classical definition of ambient and focal SA/FD definitions*

Does SA stay relevant to denominate the clusters? Verifying on spatial deployment.
Focal Fixations are object-based

- **Saliency**
  - **With object**: Focal are more attracted by the saliency than ambient
  - **Without object**: No difference between ambient and focal
  - **Focal fixations**: are more attracted by the saliency with presence of objects
  - **Ambient fixations**: show same attractiveness with or without objects

  Focal saliency attractiveness is due to object saliency

- **Mapping In/out of objects**
  - 74% of **ambient fixations** are out of Object
  - 43% of **focal fixations** are on object AOI
  - 82% of **object fixations** are **focal**

- **Object phase**: 1 second

  Focal fixations

  SA remains a relevant index
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Experiment 3: Ambient fixations vs Global Scene processing

- **Focal fixations** are object and saliency-based
- There are less **ambient fixations**

**Question:** Does it mean that **ambient fixations** are noise or **functional fixations**?

**Hypothesis:** **Ambient fixations** deployment allows a **global scene processing**

- Should **fast scene categorization** be facilitated by the **ambient extraction**?
**Protocol**

- Rapid scene categorization task
- Go/no-go paradigm (28 subjects)
- **Stimuli**: Coast versus Street
  - Target = Street
- Prime insertion (50 ms)

Principle: To illuminate fixated regions

**4 priming conditions**

<table>
<thead>
<tr>
<th>Original</th>
<th>Ambient</th>
<th>Focal</th>
<th>Saliency</th>
<th>Random</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="original_image.jpg" alt="Image" /></td>
<td><img src="ambient_image.jpg" alt="Image" /></td>
<td><img src="focal_image.jpg" alt="Image" /></td>
<td><img src="saliency_image.jpg" alt="Image" /></td>
<td><img src="random_image.jpg" alt="Image" /></td>
</tr>
</tbody>
</table>
3 associations
   prime / target

Image congruence
No congruence
Categorical congruence
Results: Reaction Time

- **Image congruence**
  - Ambient extraction facilitates global scene categorization

- **Categorical congruence**
  - **Image** and **category** congruence conditions allow an equal facilitation
  - Supports that ambient fixations mediate a global category representation as a « *contextual frame* » (Bar, 03) or a « *scene gist* » (Oliva, 05)
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Conclusion

- Are there many kinds of fixations? Yes
- Have they different functions? Yes

- What is the impact on the understanding of attention? Saliency attractiveness is due to the focal object attractiveness and ambient deployment allows scene processing.

- What is the impact on computational modeling? It explains performances and limitations of saliency maps.
Conclusion

Contributions

Experiment 1
- **Automatic method** to classify fixations
- Importance of *saccade amplitude*
- **Focal nature** of saliency

Experiment 2
- Relationship between the *object processing* function and *focal fixations*
  - Across the saliency attractiveness
  - By the spatial deployment on object
  - By the time and functional correlation
- Object filtering **method**

Experiment 3
- Relationship between the *scene categorization* function and *ambient fixations*
  - Ambient extraction facilitates scene categorization
- Fixation-based priming **method**
Conclusion

Contributions

Computationnal approach
- Independence between centered bias and saliency
- Stronger gaze prediction of medium frequencies
- Object attraction is medium frequencies-based

Papers
Perspectives

- **Ambient** and **focal** fixations are preferentially distinct by SA
  - But indexes are not really stable
    - *Research about* **data separability**
      - Other features
      - Other algorithms
      - Number of clusters > 2
  - *Research about* **fixation duration**
    - Associated function ?
    - Relationship with saliency

- **Bottom-up SM** are **focal** models
  - How to model ambient SM ?
    - *Research about* **ambient prediction**
      - Global factors

technicolor applications
  - Reframing
  - Compression
Thank you for your attention