Preparing and Presenting Complex Images for Perceptual Cognitive Studies

Javid Sadr (sadr@uleth.ca)
Departments of Psychology and Neuroscience, University of Lethbridge
4401 University Drive, Lethbridge, AB T1K 3M4 CANADA
tel.: 403.332.4530, fax: 403.329.2555

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Introduction: Objectives and Scope

The goal of this tutorial is to reduce the "barriers of entry" for cognitive scientists interested in studying perceptual/ cognitive processes with complex, real-world stimuli - and in doing so with confidence in their underlying techniques and conceptual approach. The content of this session will span basic topics in the selection/creation and (crucial) pre-processing of complex images; powerful stimulus manipulation techniques, including image degradation and filtering methods; and important considerations in experimental presentation (e.g., display choice and calibration, web-based studies) and design of perceptual-cognitive tasks/paradigms.

Motivations, Applications, and Audience

From even a quick survey of publications in the field, it's clear that interest in perceptual (particularly visual) research in the cognitive sciences is not merely enormous but ever-growing. This is not surprising in a sense: the role of perceptual processes in cognition can hardly be overstated, and in some ways it's hard to imagine one without the other.

However, many studies limit themselves, for good reason, to very basic visual stimuli (e.g., dots, lines, simple shapes), while in other studies the move to complex stimuli and high-level perceptual/cognitive phenomena (e.g., object, face, and scene perception) has at times led to unfortunate missteps or misinterpretations relating to stimulus control, manipulation, and experimental presentation or task design - including potential confounds in behavioural and neural measures resulting from low-level image properties. A very simple example (Fig. 1) illustrates how attempts to study spatial-frequency effects in a perception task could coincide with large shifts in image contrast, a critical stimulus variable; such confounds may plague a variety of stimuli and image manipulations, greatly undermining a study's findings and interpretations (e.g., Rainer et al, 2001).

We have previously reviewed in detail a wide range of these methodological concerns, consequences, and corrective measures (Sadr & Sinha, 2001a, 2004), and the fundamental concepts and techniques covered in this tutorial (informed in part by our technical and experimental work [e.g., Sadr & Sinha, 2001a, 2001b, 2003, 2004; Mack, Gauthier, Sadr & Palmeri, 2008; Willenbockel et al, 2010]) are now being employed in a wide range of cognitive and neuro- science research, including: developmental and clinical studies (e.g., Bernstein, Loftus & Meltzoff, 2005; Pollack & Sinha, 2002); neural correlates of perception, perceptual learning, and new measures of priming (Eger, Henson, Driver & Dolan, 2007; Liu, Harris & Kanwisher, 2002; Sadr & Sinha, 2003, 2004); dissociating sequential stages of object and face processing (Liu, Harris & Kanwisher, 2002; Mack, Gauthier, Sadr & Palmeri, 2008); mechanisms of scene perception and explorations of different masking techniques/stimuli (Loschky et al, 2010).

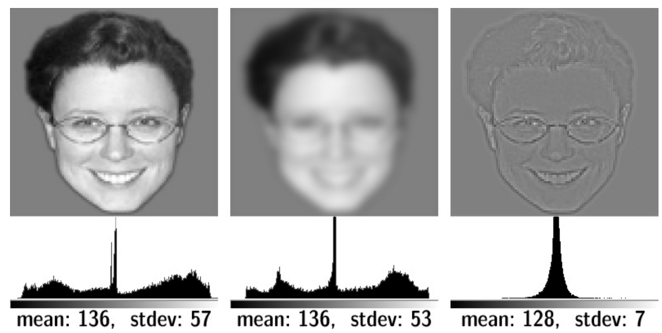

Figure 1: Original image versus typical low-pass ("blur") and high-pass ("edge") images: potential confound in image contrast, seen in luminance histogram's standard deviation.

With sharply growing interest and activity in such research areas, and a enduring concern for implementing these techniques soundly, this tutorial is tailored for scientists interested in, but new to, higher-level perceptual/ cognitive processes and complex images, as well as those currently exploring such research but perhaps seeking greater comfort with and intuition for underlying techniques and concepts. Given the diversity of the audience, our session is intended to be flexible in its scope, depth, and progression and is primarily conceived at a level well-suited to a range of participants, from those with little or no background to those with an intermediate level of experience.

Tutorial Approach and Participation

Our tutorial's overall structure will follow a progression of core topics and techniques, from basic concepts and handling of images all the way to stimulus manipulation and experimental presentation. Along the way, we will try to address questions and requests regarding subtopics or special applications as fitting the participants' interests. At each step, the topics and techniques will be illustrated by the tutorial organizer or optionally performed as activities by participants who might wish to bring a computer. Tutorial content will be provided partly in print (e.g., content from presentations) and partly via electronic resources online.

Participants are not required to bring a computer (nor purchase special software/tools). Those who do will have access to resources and activities (i.e., sample images, scripts, etc.) to augment the tutorial (e.g., pre-processing and normalizing a set of source images [Fig. 2], manipulating stimuli for specific applications [Fig. 3], etc.), and those attending without a computer will be likewise engaged in applied examples and demonstrations led by the tutorial organizer. Overall, our goal is a valuable experience for all participants, whether they wish to explore these techniques at certain points during the session itself or to do so at their leisure following the tutorial.

Figure 2: Stimuli pre-processed with identical low-level properties: luminance, contrast, spatial freq.; only means of discrimination is via visual structure from phase coherence.

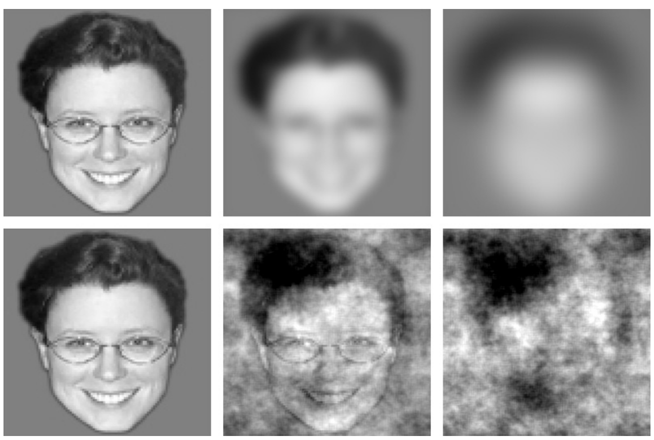

Figure 3: Different approaches to image degradation; e.g., typical Gaussian blur vs. Fourier phase manipulation (which can preserve luminance, contrast, and spatial frequencies).

Background

From the outset, this session is planned specifically for the needs, interests, and backgrounds of participants we anticipate at this year's Cognitive Science Society conference. The tutorial's approach, content, and instruction are built on extensive experience teaching and training cognitive science and neuroscience students, colleagues, and collaborators these core topics and techniques in high-level perceptual/cognitive research.

The tutorial organizer has over ten years' experience specific to perceptual/cognitive studies using complex visual stimuli and corresponding image-processing and experimental methodology. Along with related studies using both dynamic and static visual stimuli, this work has been disseminated, both in terms of underlying methods (e.g., image pre-processing, manipulation, and unique task paradigms) and applications (e.g., object perceptual priming, stages of processing), in a series of publications and presentations over the last decade, including a key methods paper in *Cognitive Science* (Sadr & Sinha, 2004; following Sadr & Sinha, 2001a, 2001b). Even so, this is the first occasion for us to directly share these concepts and skills - and the insights and intuitions we've gained - with a broad base of interested researchers in an interactive setting.

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