Reference to previous work might be extended, especially concerning research in perception. In fact, although in my understanding, the presented work is about lightness constancy, there is no definition of lightness and it is not clear what are the factors involved in lightness constancy. For a definition of lightness and brightness I recommend referring to "Lightness Perception and Lightness Illusions"- Adelson, 2000. For the factors contributing to lightness constancy I suggest "Seeing black and white" - Gilchrist, 2006.

We modified the end of the first paragraph to add a definition of lightness constancy and to include some key references:

"The ability of a visual system to compute a representation of object color that is stable against variation in object-extrinsic factors is called color constancy. A well-studied special case of color constancy is when the stimuli are restricted to be achromatic. This special case is called lightness constancy (Gilchrist, 2006). Although human lightness and color constancy are not perfect, they are often very good (Foster, 2011; Brainard & Radonjic, 2014; Adelson, 2000; Kingdom, 2011)."

Adelson, E.H. 2000 Lightness perception and lightness illusions. In *The New Cognitive Neurosciences, 2nd ed.* (ed. M. Gazzaniga), pp. 339-351. Cambridge, MA, MIT Press.

Gilchrist, A.L. 2006 *Seeing Black and White*. Oxford, Oxford University Press.

Kingdom, F.A.A. 2011 Lightness, brightness and transparency: A quarter century of new ideas, captivating demonstrations and unrelenting controversy. *Vision Research* **51**, 652-673.

Also, fix citations to Radonjic -> Radonjić

Also, there is a certain body of work on which scenes aspects potential cues for lightness (e.g "Cues to an Equivalent Lighting Model" Boyaci, Doerschner & Maloney, 2006; "Illumination estimation in three-dimensional scenes with and without specular cues" - Snyder, Doerschner & Maloney). Specular reflections are one of those cues. However, there are human and simulation studies reporting that specular highlight are discounted in lightness judgments and that specular reflections potentially impair lightness discrimination (e.g. "Lightness constancy in the presence of specular highlights" - Todd, Normal & Mingolla, 2004; "Lightness perception for matte and glossy complex shapes", Toscani, Valsecchi & Gegenfurtner, 2017; "The effect of gloss on perceived lightness" - Beck, 1964 ).

We agree that providing a bit more in the way of pointers into the relevant literature will be helpful, although reviewing this literature is beyond the scope of the current paper. We have now edited the following paragraph in the discussion, and added citations along the lines suggested above. [David to look for where to do this.]

"In the work presented here, we studied computational luminance constancy in virtual scenes with naturalistic spectral variation in light sources and in surface reflectance functions, with only matte surfaces in the scenes. It is natural to by studying with spectral variation, because this variation is at the heart of what makes luminance constancy a rich computational problem. In natural scenes, however, there are other sources of variation that add additional richness. These include variation in non-spectral properties of objects and lighting in the scene, including object texture, material, and shape as well as lighting geometry. The methods we developed here may be generalized to study the effects of variation in these factors. That is, one could incorporate these other sources of variation into the generation of the scenes and again learn estimators from the corresponding labeled images. A challenge for this approach will be to thoughtfully control the increase in problem complexity, both to keep compute time feasible and to ensure that it is possible to extract meaningful insight from the results. We note that there is a growing literature on how increasing stimulus complexity along the various lines listed above affects human color and lightness perception and constancy (Beck, 1964; Yang & Maloney, 2001; Yang & Shevell, 2002; Todd et al., 2004; Snyder et al., 2005; Boyaci et al., 2006; Xiao & Brainard, 2008; Xiao et al., 2012; Toscani et al., 2017; refs), as well as the computational problem of color and lightness constancy (Lee, 1986; D'Zmura & Lennie, 1986; refs)."

Beck, J. 1964 The effect of surface gloss on perceived lightness. *American Journal of Psychology* **77**, 54-63. – Highlights affect perceived lightness

Todd, J.T., Norman, J.F. & Mingolla, E. 2004 Lightness constancy in the presence of specular highlights. *Psychological Science* **15**, 33-39. – Specular highlights discounted in lightness perception.

Boyaci, H., Doerschner, K. & Maloney, L.T. 2006 Cues to an equivalent lighting model. *J Vis* **6**, 106-118. – Review of that lab's work. Not quite what we want here.

Snyder, J.L., Doerschner, K. & Maloney, L.T. 2005 Illumination estimation in three-dimensional scenes with and without specular cues. *J Vis* **5**, 863-877. – Specularities improve constancy.

Toscani, M., Valsecchi, M. & Gegenfurtner, K.R. 2017 Lightness perception for matte and glossy complex shapes. *Vision Res* **131**, 82-95. – Highlights affect perceived lightness of glossy surfaces.

Yang, J.N. & Maloney, L.T. 2001 Illuminant cues in surface color perception: tests of three candidate cues. *Vision Research* **41**, 2581-2600. – Hightlights can improve constancy.

Yang, J.N. & Shevell, S.K. 2002 Stereo disparity improves color constancy. *Vision Research* **42**, 1979-1989. – Constancy improves with stereo when there are highlights.

Lee, H.C. 1986 Method for computing the scene-illuminant chromaticity from specular highlights. *Journal of The Optical Society of America A* **3**, 1694-1699. – How specularities could improve color constancy.

Xiao, B. & Brainard, D.H. 2008 Surface gloss and color perception of 3D objects. *Visual Neuroscience* **25**, 371-385. – Object color appearance is somewhat stabilized against desaturation from specular highlights

Xiao, B., Hurst, B., MacIntyre, L. & Brainard, D.H. 2012 The color constancy of three-dimensional objects. *Journal of Vision* **12**, 1-15. – No improvement of constancy with addition of highlights.

D'Zmura, M. & Lennie, P. 1986 Mechanisms of color constancy. *Journal of the Optical Society of America A* **3**, 1662-1672. – How specularities could improve color constancy.

Tominaga, S. & Wandell, B.A. 1989 The standard surface reflectance model and illuminant estimation. *Journal of the Optical Society of America A* **6**, 576-584. – How specularities could improve color constancy.

I think that the approach presented in the manuscript might help investigating the role of specular highlights for an ideal observers. In fact, with a fixed geometry of the scene and the illumination (as it was in the reported simulations) the distribution of the weights in the receptive fields is informative about the role of the elements in the scene. Given the interest that specular reflection received by color and lightness constancy investigations, I would add this in the "Future Directions" section.

Good point. We have adopted this suggestion. [Vijay to draft in the discussion.]

Also, I suggest stating that the rendered scenes were matte in the "Images of Virtual vs. Real Scenes" section, as a limitation of the simulation given that specular reflections might interact with lightness constancy, as discussed in the literature.

This restriction is now noted explicitly as part of the inclusion of the point above.

Classical ("Lightness and retinex theory", Land & McCann, 1971) but also recent theories of lightness constancy ("A cortical edge-integration model of object-based lightness computation that explains effects of spatial context and individual differences" - Rudd, 2014) propose that visual system spatially integrates the luminance steps corresponding to reflectance edges (as given object boundaries). By looking at the shape of the receptive field in condition 3, it seems that rather large positive weights are flanked by negative weights corresponding to borders between the objects in the background, suggesting edge related computations. I suppose one of the potentiality of the approach is to reveal such local computations, thus if the authors find my speculation sensible, I would add it in the discussion, showing how the proposed approach has the power to reveal lightness constancy computations as proposed in the literature.

This is an interesting connection, which we now make. A full test would require variation of the geometry of the scene and an understanding of what RFs are optimal for that case, a manipulation that represents an interesting direction for future studies. [David to have a go at this.]

The idea of generating large datasets of rendered surfaces in order to investigate classification of an ideal observers (ROC and linear classification) on their material properties is not new ("Optimal sampling of visual information for lightness judgments" - Toscani, Valsecchi & Gegenfurtner 2013; "Lightness perception for matte and glossy complex shapes" - Toscani, Valsecchi & Gegenfurtner 2017; "Statistical correlates of perceived gloss in natural images" -Wiebel, Toscani & Gegenfurtner, 2015).

However, to my knowledge this is the first time that reflectance spectra are taken into account, as opposed to grayscale images, as the toolbox presented in the paper allows. I would stress the novelty respect to previous work.

Let's take a look at these papers and then discuss them appropriately. [David and Vijay to have a look at these and figure out what to say about them.]

The distribution of surface albedos in natural environments is approximated by a specific beta distribution ("The distribution of reflectances within the visual environment", Attewell & Baddeley, 2006) and the discernible colors present in nature only cover a specific portion of theoretical solid of visible colors ("The number of discernible colors in natural scenes" Linhares, Pinto & Nascimento, 2008). For the simulation presented in the manuscript, reflectance spectra are sampled from a statistical model approximating a largely variable set of colors, as the Munsell chips is supposed to represent the space of visible colors rather than resembling the occurrence of colors in the word. I suppose this gives an upper limit to the limitation in performance due to the increasing complexity with conditions, and results might change considering the natural distribution of reflectance spectra.

There are databases providing a large collection of reflectance spectra or reflected spectra from isolated surfaces under a known illuminant, although they do not span color spaces as well as the munsell system. In fact, they focus on leaves fruits and vegetables ("Fruits, foliage and the evolution of primate colour vision" - Regan, Julliot, Simmen, Vienot, Charles-Dominique & Mollon, 2011; "Hyperspectral database of fruits and vegetables" - Ennis, Schiller, Toscani & Gegenfurtner, 2018).

This seems like a good point to discuss. I am not sure these data are available, but we might have a look at the papers and then see.

I found only one typo at the end of page 2: "(?, ?; Brainard and Freeman, 1997)", probably due to the reference manager.

Fixed. [Carefully check submission for any such typos, search on "?" in PDF, etc.]

I would find interesting to have the shape of the receptive fields reported also for the analysis about the scenes in condition 2.

We have added these to the appendix.

Other Changes:

We improved this paragraph in the discussion by adding relevant citations:

"Unfortunately, such datasets are not readily available for studying correlates of object surface reflectance. To obtain ground truth information about the reflectance of objects in a natural image, it is necessary to make an independent measurement of the of the reflectance function of each object (or of the illumination impinging on each object). Although this can be done at a small number of image locations by inserting discretely spaced reflectance standards into the scene, interpolating to locations between such standards requires strong assumptions that are often unjustified in real scenes."