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Decoupling category level and perceptual similarity in congenital prosopagnosia

Alison Campbell & James W. Tanaka

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COMMENTARY

Decoupling category level and perceptual similarity in congenital prosopagnosia

Alison Campbell and James W. Tanaka

Department of Psychology, University of Victoria, Victoria, BC, Canada

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In their review, Geskin and Berhmann re-examined 716 cases of congenital prosopagnosia (CP) to determine the prevalence of object recognition deficits that were associated with impaired face recognition. The authors specified that certain experimental criteria needed to be met when comparing performance on an object recognition task to performance on a face recognition task. According to Geskin and Behrmann, "best practices" for comparing object and face recognition should include reaction time (RT) data to measure the accessibility of face and object representations and should employ tests of object recognition that are equated to face recognition. When these factors are taken into account, the authors found that the majority of CP cases in the literature did not reflect "pure" cases of prosopagnosia, but many patients exhibited a mix of impaired face and object recognition. The authors interpreted these results as showing that CP involves abnormal development of a mechanism that is not specific to faces. Combined with the paucity of cases of object agnosia without consequences to face processing, the results lead the authors to propose that face recognition may be an especially difficult instance of object recognition.

However, problematic for this interpretation was the small number of pure prosopagnosic patients (i.e., 47 cases of the 459 cases tested on objects) who showed preserved object recognition abilities as measured by normal accuracy and response times. The aim of this commentary is to re-examine the role of categorization in face and object recognition tasks and to differentiate between two separable factors that modulate the perceptual processing demands of a task: the level at which stimuli must be categorized and the perceptual homogeneity of the stimuli. We argue that the majority of the reported cases of pure CP employed discrimination tests that failed to provide a fair test of object and face discrimination abilities because they manipulated the level of categorization but neglected to control for perceptual similarity. Because of an inequality in the perceptual homogeneity of the stimulus sets, we find that the number of CP cases with intact object recognition is reduced from 47 to 6, thereby casting further doubt on the common view that CP reflects a deficit that is specific to faces.

Of the 47 pure cases, 40 cases were determined to have unimpaired object recognition based on a test developed to compare categorization for faces and objects (Grill-Spector, Knouf, & Kanwisher, 2004; Zhao et al., 2016; Zhu, Zhang, Luo, Dilks, & Liu, 2011). In this task, participants are shown a series of object images and are required to identify pre-defined target exemplars from other category members within a basic category. For example, participants are required to detect pigeons amongst distractor birds (e.g., warbler, sparrow), roses amongst distractor flowers (e.g., hibiscus, daisy), and Jeeps amongst distractor vehicles (e.g., vintage automobile, modern sedan). In the face version of the task, participants are required to detect an identity target such as Harrison Ford from other famous and non-famous identities.

The obvious problem with this task is that the perceptual similarity between a pigeon and a warbler is not equated with the perceptual similarity between individual faces. Consequently, any differences in processing due to visual class (face vs. object) cannot be disentangled from differences in the perceptual homogeneity in the two conditions. The finding that CP participants are able to complete this task does not, therefore, discount an explanation of face recognition as a particularly difficult form of object recognition.

CONTACT Alison Campbell campbel1@uvic.ca

This problem highlights a deeper issue in the common approach of comparing recognition of faces to the recognition of within-category objects. Although faces and objects differ both in the physical properties of the stimuli themselves and in task-related characteristics (e.g., the number of known exemplars, social importance), the dimension that has been most emphasized is the category level at which the two classes are most readily processed. Whereas faces are recognized most quickly at the identity level ("Brad Pitt"; Tanaka, 2001), objects are more quickly recognized at more general, basic category levels ("bird"). Moreover, behavioural (Jolicoeur, Gluck, & Kosslyn, 1984; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976), electrophysiological (Tanaka, Luu, Weisbrod, & Kiefer, 1999), and neuroimaging (Gauthier, Anderson, Tarr, Skudlarski, & Gore, 1997) evidence suggests that additional perceptual processing is needed for more specific levels of categorization. For example, for the exact same image (e.g., a pelican), forcing a more specific category judgment ("pelican") leads to greater brain activity in areas associated with face recognition compared a basic level category judgment ("bird"; Gauthier et al., 1997). Critically, since the images used in the two conditions were the same, the increase in activity can only be attributable to the category level at which the image was being judged. This showed that brain areas that activate to faces are sensitive not only to physical stimulus characteristics but also to the level of categorization. Thus, it is possible that differences in face and object recognition can be attributable to the level of categorization at which they tend to be processed even before taking into account the physical differences between face and object stimuli.

However, subordinate level category members can differ significantly in their structural similarity to one another, and, as a consequence, it may be more perceptually demanding to discriminate one subordinate object from its distractors than another subordinate object. For example, Grill-Spector et al. (2004) and Dennett et al. (2012) developed tasks to test subordinate level discrimination of cars. In the Grill-Spector et al. (2004) measure, the task is to identify a target Jeep object from perceptually dissimilar sedans, whereas in the Cambridge Car Memory Task (Dennett et al., 2012), the task is to identify a target sedan from other more structurally similar sedans. Although the two tasks are equated for subordinate level discrimination, they are not equated for the perceptual demands required for the subordinate level judgment. It is possible that a CP participant might show spared object discrimination processes on the easier "Jeep" task, but show impaired object processing on the more difficult "sedan" task.

Of course, there remains a large gap in the perceptual demands required for subordinate-level object recognition and the identity-level judgments required for face recognition. Few cases in the CP literature test for identity-level recognition of objects; the one exception is the CP participant OH, who has the ability to recognize individual horses (Weiss, Mardo, & Avidan, 2016). OH self-reported that she was able to identify horses at her barn and at competitions but has trouble remembering familiar faces. Two tests were used to substantiate her expertise and to compare performance to other horse experts and non-expert controls. In the first, participants were shown pairs of horse images and were required to indicate whether the horses were of the same breed. Although the second test involved discriminating between horses of the same breed, the task involved matching identical images of a particular horse and discriminating from a third distractor. Because the first only tests discrimination of horses at the breed level and the second task can be completed by image matching, neither of these tasks manipulate the perceptual homogeneity of the items between which participants are required to discriminate. Therefore, OH's ability to complete these tasks also does not rule out the possibility that her abnormal performance on the Cambridge Face Memory Task is due to a deficit in discriminating between perceptually homogenous, more "difficult" stimuli. Furthermore, although she did score within the normal limits on the Cambridge Car Memory Task, it remains unknown whether her reaction time is normal for recognizing objects for which she has no extensive experience.

Although it is possible that real-world task demands of horse identification do involve discriminating between perceptually homogenous horses, it is unknown if the 13 horses residing at the farm where she works are of the same breed. This demonstrates how category specificity and perceptual homogeneity can diverge: homogeneity will only be maximal at the identity level (relative to less specific category levels) *if* the token identities are of the same type. Unlike the recognition of faces, expert horse recognition was not associated with face-like inversion effects or orientation-dependent gaze patterns. Lack of face-like processing may therefore reflect the multiplicity of the horse types that horse experts identify. On the other hand, expert identity level recognition for dogs of the same breed (Diamond & Carey, 1986) and for birds of the same species (Campbell & Tanaka, 2014) have both been shown to be orientation-dependent in the same way as face recognition (e.g., Yin, 1969; but see Robbins & McKone, 2007). Although it is not realistic, perhaps the best demonstration of a pure CP participant would be a person who exhibits a spared ability to individuate structurally homogenous objects like dogs of the same breeds or birds of the same species but an impaired ability to individuate faces.

In closing, the purpose of this commentary has been to decouple the factors of category level and structural similarity in object and face processing. We argue that equating objects according to their category level does not necessarily equate them for their structural similarity—that is, objects that share the same subordinate category level might look very similar or very different from one another and therefore vary in the perceptual demands required to discriminate them. When category level and perceptual similarity are separated, we argue that 41 cases of CP classified as pure (Weiss et al., 2016; Zhao et al., 2016) are based on object tasks that fail to control for perceptual homogeneity, thereby reducing the evidence for pure CP cases from 47 to 6. Not only do these dwindling numbers suggest a need to reconceptualize the deficit inherent to CP; more generally, they demonstrate the need for more care in the design of object recognition tests based on the criteria of category level and perceptual similarity.

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ORCID

Alison Campbell http://orcid.org/0000-0001-6891-8609

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