



## Viewpoint costs occur during consolidation: Evidence from the attentional blink<sup>☆, ☆☆</sup>

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### Abstract

Do the viewpoint costs incurred when naming rotated familiar objects arise during initial identification or during consolidation? To answer this question we employed an attentional blink (AB) task where two target objects appeared amongst a rapid stream of distractor objects. Our assumption was that while both targets and distractors undergo initial identification only targets are consolidated in a form that allows overt report. We presented line drawings of objects with a usual upright canonical orientation, and separately manipulated the orientation of targets and distractors. In two experiments, targets were defined by colour, whereas in a third experiment they were defined by semantic category. Target 1 orientation influenced the AB, with objects rotated by 90° causing a larger second target deficit than upright and upside-down objects. However, distractor orientation did not affect the magnitude of the second target deficit, regardless of whether targets were defined by colour or semantic category. Taken together, these findings suggest that the visual representations involved in the preliminary recognition of familiar objects are viewpoint-invariant and that viewpoint costs are incurred when these objects are consolidated for report.

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When asked to name familiar objects, subjects typically demonstrate a systematic decrease in recognition performance, as measured by reaction time and/or accuracy, when the stimuli are increasingly misoriented from their most common (e.g., upright) view (Jolicoeur, 1985). This finding has been interpreted as evidence for the existence of *viewpoint-dependent* object representations. It is generally believed that these viewpoint costs arise during the initial recognition of stimuli, as objects are matched (via some sort of mental transformation) to a stored representation (e.g., Bülthoff & Edelman, 1992; Jolicoeur, 1990; Tarr & Pinker, 1989). However, a number of researchers have also postulated that the representations that support familiar object recognition are *viewpoint-invariant* (e.g., Corballis, 1988). Proponents of this view suggest that object representations are based on stimulus features and how they interrelate, which remain unchanged as the orientation of an object is manipulated.

We have recently demonstrated orientation-invariant recognition of familiar objects under conditions of *rapid serial visual presentation* (RSVP), using a *repetition blindness* (RB) paradigm (Harris & Dux, 2005a, 2005b). RB is characterised by subjects' decreased ability to report both occurrences of a repeated stimulus, relative to reporting two stimuli with different identities, if they are presented within 500 ms of one another. A number of theories have been proposed to account for this effect, the dominant perspective being that RB reflects a failure to bind a second episodic token to a repeatedly activated stored representation (type; Chun, 1997; Kanwisher, 1987). Thus, we reasoned that if recognition of familiar objects is independent of viewpoint, then RB should be found between identical objects even if they are presented in different orientations, as both occurrences of the stimulus would activate the same viewpoint-invariant representation. To test this, we presented streams of three pictures for 100 ms each, with masks at either end of the stream. The subjects' task was to report the three objects. The first and third items were either identical or different objects and differed in picture-plane orientation by 0°, 30°, 60°, 90° or 180°. RB occurred across all orientations, suggesting that the representations involved in RB are invariant with respect to viewpoint changes in the picture plane.

The presence of RB indicates that, at some level, a repeated stimulus is registered as identical to an earlier stimulus. Thus, our previous results suggest that viewpoint information is *not* coded at this stage of initial perception. In our earlier study, we proposed that viewpoint costs arise during consolidation, when a stimulus is coded in a form that can support overt or conscious recognition (Harris & Dux, 2005a). However, this hypothesis remains to be tested and the precise locus of these effects is still unknown.

In the present study we examined whether the naming costs associated with recognising rotated familiar objects have their locus during consolidation, by employing another RSVP phenomenon – the *attentional blink* (AB; Raymond, Shapiro, & Arnell, 1992). The AB refers to subjects' decreased ability to report the second of two different target items in a RSVP stream if it appears within 500 ms of Target 1. A number of models have been proposed to account for this effect (e.g., see Shapiro, Arnell, & Raymond, 1997, for a review) and, although there are some

differences among these theories, there is now a general consensus that most items in a RSVP stream are initially recognised, but require additional processing if they are to be reported. It is this additional, capacity limited, processing that causes the deficit in reporting the second target, as stimuli in close temporal proximity to Target 1 must wait to be consolidated and consequently their initial representations are more susceptible to decay and interruption from trailing items (Chun & Potter, 1995; Jolicoeur, 1999).

There are two lines of evidence which support the hypothesis that the AB occurs due to a consolidation bottleneck. Firstly, there is strong evidence from behavioural (Dux & Coltheart, 2005; Maki, Frigen, & Paulson, 1997; Shapiro et al., 1997) and neuro-imaging (Luck, Vogel, & Shapiro, 1996; Marois, Yi, & Chun, 2004; Vogel, Luck, & Shapiro, 1998) studies that most stimuli in a RSVP stream make contact with high-level representations. This suggests that selection in dual-target RSVP tasks occurs after stimuli have been briefly identified (Potter, 1975). Secondly, many studies have demonstrated that the magnitude of the AB is positively correlated with Target 1 task difficulty (e.g., Grandison, Ghirardelli, & Egeth, 1997; Jolicoeur, 1999; Olson, Chun, & Anderson, 2001; but see McLaughlin, Shore, & Klein, 2001). It has been hypothesised that on difficult Target 1 trials, Target 2 is more likely to be missed because it has to wait for longer before it enters the bottleneck and undergoes consolidation.

In the present study, we exploited these two characteristics of the AB to test whether the viewpoint costs associated with recognising rotated familiar objects are incurred during initial identification or during consolidation. In Experiments 1 and 2, we tested the hypothesis that the initial identification of familiar objects is viewpoint-invariant, by manipulating the orientation of the distractors. In Experiment 1, the targets were defined by colour (red objects amongst black distractors), whereas in Experiment 2, targets were defined by category (animals amongst inanimate objects). As mentioned above, there is good evidence that distractors activate their long-term representations, however, because they do not require report, they usually do not undergo consolidation. Therefore, we predict equivalent performance for trials containing upright vs. rotated distractors. In Experiment 3, we tested whether *more* attentional resources are required to consolidate misoriented objects than objects presented in their regular canonical orientation. To do this we manipulated the orientation of Target 1 while presenting Target 2 and the distractors in their regular upright orientation. If rotated objects require more resources to be consolidated than upright objects, a larger AB should be observed when Target 1 is rotated, because Target 2 consolidation will be delayed in these trials, relative to trials where Target 1 is upright.

## 1. General method

### 1.1. Subjects

Twelve different members of the Macquarie University community took part in each of Experiments 1 and 3. For Experiment 2, 20 members of the University of Sydney community participated. All the subjects reported normal or corrected-to-normal visual acuity.

### 1.2. Apparatus

Stimuli were presented on a flat 19 in. monitor with either a 120 Hz (Experiments 1 and 3) or 85 Hz (Experiment 2) vertical refresh rate, controlled by a PC computer. The experiments were programmed and conducted using DMDX software (Forster & Forster, 2003).

### 1.3. Stimuli and design

The stimuli were pictures from the Snodgrass and Vanderwart (1980) corpus, chosen to have a well-defined upright orientation. In Experiments 1 and 3, 50 objects were used, 30 of these being target items and the remaining 20 distractors. In Experiment 2, 70 objects were presented, 30 as targets (animals) and the remaining 40 as distractors (inanimate objects). The stimuli were presented as black line drawings, with the exception of the target items in Experiments 1 and 3, which appeared in red. Each trial consisted of 2 targets and 12 distractors, each presented for approximately 100 ms (100.2 ms in Experiments 1 and 3 and 106 ms in Experiment 2) with no *inter-stimulus interval* (ISI). Target 1 could appear at serial positions 2–6 in the stream and Target 2 followed with a variable lag (1–6 items). All the stimuli were presented on a white background and subtended 12° of visual angle at the viewing distance of 45 cm. In addition, each trial began with a black fixation cross (+), for 300 ms, and ended with a “&” mask. Fig. 1 shows examples of the stimuli and trial composition.

Experiments 1 and 2 had identical 2 × 6 repeated measures designs, and only differed in the task required of the subject (“name the red objects” in Experiment 1 and “name the animals” in Experiment 2). The first independent variable was

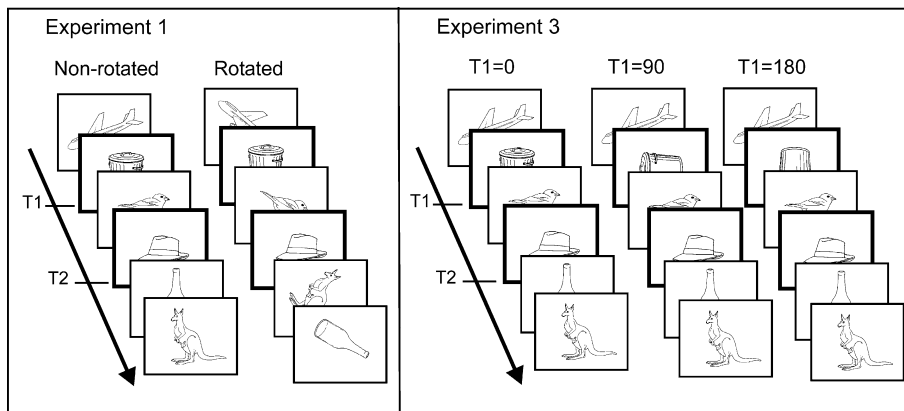


Fig. 1. Illustrations of the experimental trials in Experiments 1 and 3 (Experiment 2 had an identical design to Experiment 1). In Experiment 1, half the trials contained upright distractors and the other half contained rotated distractors; targets were always upright. In Experiment 3, the orientation of Target 1 (T1) was either 0°, 90°, or 180°, while Target 2 (T2) and the distractors were upright. Targets are identified by bold outline here, but appeared as red line drawings in the actual experiment. T1 could appear at serial position 2–6, with T2 following at variable lags (1–6).

**Distractor Orientation:** Distractors were either all upright or all rotated (a random mix of 30°, 60° and 120° in Experiment 1 and 60°, 90° and 120° in Experiment 2). The second independent variable was the Lag between the two targets, which had six levels: Lags 1–6. Experiment 3 had a 3 × 6 repeated measures design. The first independent variable was Target 1 Orientation, which had three levels: 0°, 90° or 180°. The second independent variable was Lag. There were 10 trials in each condition, making a total of 120 trials in Experiments 1 and 2 and 180 trials in Experiment 3.

#### 1.4. Procedure

Subjects initiated each trial by pressing the space bar. At the end of the trial, a message appeared on the screen prompting subjects to verbally recall the targets (red objects in Experiments 1 and 3 and animals in Experiment 2). The experiments were divided into two blocks of equal length, with all the conditions fully randomised within each block. Before starting the experiment, subjects received 30 practice trials containing examples of each condition.

## 2. Results

For Target 2 accuracy, only those trials where Target 1 was reported correctly (T2|T1) were included in the analysis.

### 2.1. Experiment 1

In this experiment, subjects were required to name two red upright objects presented amongst upright or rotated black distractors.

#### 2.1.1. T2|T1 accuracy

Fig. 2 shows the mean percentage T2|T1 accuracy as a function of Distractor Orientation and Lag. The T2|T1 accuracy data were subjected to a 2 × 6 repeated measures ANOVA.

The only significant result was the main effect of Lag,  $F(5,55) = 19.38$ ,  $p < 0.0005$ . A contrast comparing performance at early lags (Lags 1 and 2, mean accuracy = 63.1%) with performance at later lags (Lags 3–6, mean accuracy = 87.1%), demonstrated a typical AB pattern, with performance significantly worse at early lags,  $F(1,55) = 90.96$ ,  $p < 0.0001$ . There was no difference in AB magnitude between rotated and upright distractor trials, with neither the main effect of Distractor Orientation nor the interaction between Distractor Orientation and Lag approaching significance ( $F$ 's < 1). Thus, the AB was not influenced by the orientation of the distractors, suggesting that orientation is not coded during initial identification of an item.

#### 2.1.2. T1 accuracy

The T1 accuracy data were analysed using the same 2 × 6 repeated measures ANOVA with Distractor Orientation and Lag as within-subject factors. The main

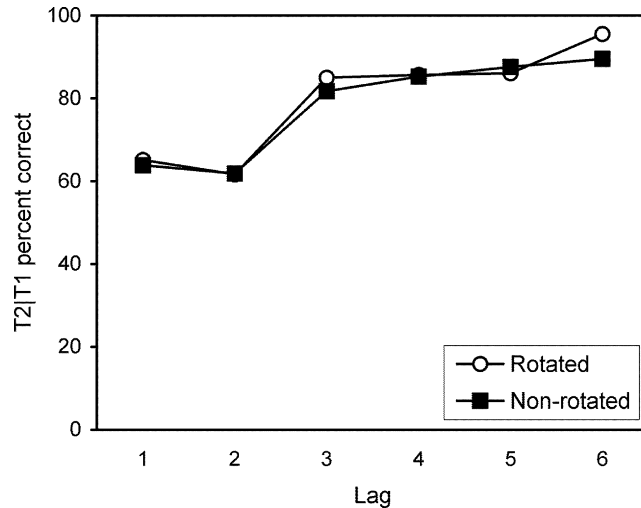


Fig. 2. T2/T1 accuracy as a function of Distractor Orientation and Lag in Experiment 1.

effects of Distractor Orientation,  $F(1, 11) = 1.4$ ,  $p = 0.26$ , and Lag,  $F(5, 55) = 2.14$ ,  $p = 0.8$ , were not significant, but there was a significant interaction between Distractor Orientation and Lag,  $F(5, 55) = 3.41$ ,  $p < 0.05$ . This was due to performance being lower in non-rotated trials compared to rotated ones at Lags 1 and 4, yet superior in the non-rotated condition compared to the rotated condition at Lag 2. However, none of these differences were significant after correcting for multiple comparisons ( $t$ 's  $< 2.4$ ,  $p$ 's  $> 0.04$ ).

## 2.2. Experiment 2

It is possible that the absence of an effect of distractor orientation in Experiment 1 was due to the fact that subjects did not, in fact, process the distractors' identity. Since targets were defined by colour in Experiment 1, the black distractors may have been filtered out at a very early perceptual stage, and as a result did not make contact with object identity representations, leading to an apparent null effect of orientation. It should be noted, however, that Maki et al. (1997) found that distractors semantically primed targets in an AB task where targets were defined by colour, casting some doubt on this interpretation. Nonetheless, in Experiment 2, we addressed this concern by asking subjects to select targets on the basis of semantic category, rather than colour. If subjects can perform this task successfully, this would confirm that distractors do undergo semantic processing. Moreover, the absence of a distractor orientation effect in this task would be convincing evidence that orientation is not coded during the initial processing of object identity. Therefore, in this experiment, subjects were required to name two black upright animals presented amongst upright or rotated inanimate objects.

### 2.2.1. T2|T1 accuracy

Fig. 3 shows the mean percentage T2|T1 accuracy as a function of Distractor Orientation and Lag. The T2|T1 accuracy data were subjected to a  $2 \times 6$  repeated measures ANOVA.

As was the case with Experiment 1, there was a main effect of Lag,  $F(5, 95) = 14.496$ ,  $p < 0.0002$ . A contrast comparing early to later lags demonstrated an AB pattern, with accuracy being superior across Lags 4–6 (mean = 81.4%) compared to Lags 1–3 (mean = 67.6%),  $F(1, 95) = 50.7$ ,  $p < 0.0002$ . Importantly, the Distractor Orientation main effect was not significant ( $F < 1$ ), suggesting that rotating the distractors did not influence overall performance. There was, however, a significant interaction between Distractor Orientation and Lag,  $F(5, 95) = 8.164$ ,  $p < 0.0002$ . Pairwise comparisons were carried out at all lags in order to investigate the source of this interaction. At Lag 1, performance on rotated trials was somewhat better than that on upright trials, although this difference was only marginally reliable,  $t(19) = 2.09$ ,  $p = 0.051$ , and does not survive correction for multiple comparisons. There were no differences between the two conditions at Lags 2 and 3 ( $t$ 's  $< 1.30$ ,  $p$ 's  $> 0.21$ ). Thus, the two conditions did not differ in the range of lags that is usually associated with the AB. There was a significant difference at Lag 4, with performance on rotated trials being significantly superior to that on non-rotated trials,  $t(19) = 6.21$ ,  $p < 0.001$ , which might suggest a more rapid recovery from the AB for the rotated trials than for the non-rotated trials. However, this pattern was reversed at Lags 5 and 6, where performance was significantly better for non-rotated trials, compared to rotated ones ( $t(19) = 2.56$ ,  $p < 0.02$ , and  $t(19) = 3.45$ ,  $p < 0.004$ , for Lags 5 and 6, respectively). This pattern is not consistent with a more rapid recovery from the AB, but rather suggests that the interaction arises from the fact that performance on trials with rotated distractors was more

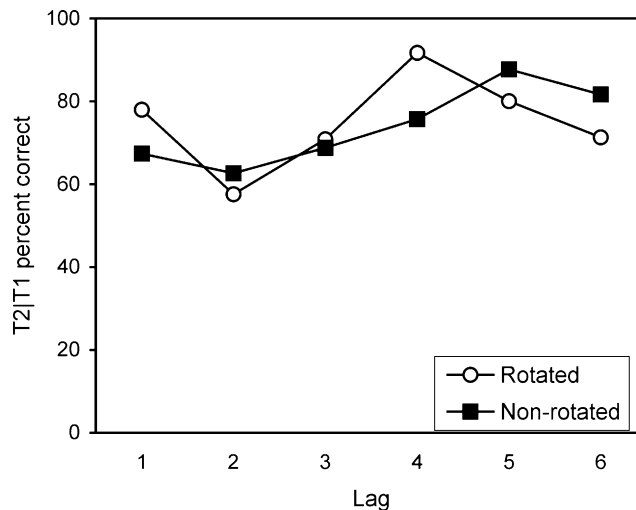


Fig. 3. T2|T1 accuracy as a function of Distractor Orientation and Lag in Experiment 2.

variable across lags, compared to performance on non-rotated trials. The reason for this variability in performance, across lag, in the rotated condition compared to the upright condition is unclear, however the results of Experiment 2 essentially mirror those of the first experiment, demonstrating that distractor orientation does not influence the AB in any systematic way.

### 2.2.2. T1 accuracy

The T1 accuracy data were analysed using a  $2 \times 6$  repeated measures ANOVA. There was a main effect of Lag,  $F(5, 95) = 19.79$ ,  $p < 0.0002$ . A contrast comparing early to late lags confirmed that accuracy was superior across Lags 4–6 (mean = 83.16%) compared to Lags 1–3 (mean = 77.25%),  $F(1, 95) = 26.3$ ,  $p < 0.0002$ . Lag also significantly interacted with Distractor Orientation,  $F(5, 95) = 7.3$ ,  $p < 0.0002$ . This was due to the fact that accuracy was lower on rotated trials compared to non-rotated trials at Lags 5 and 6 ( $t$ 's  $> 3.5$ ,  $p$ 's  $< 0.003$ ), but similar to non-rotated trials at Lags 1–4 ( $t$ 's  $< 1.9$ ,  $p$ 's  $> 0.073$ ). Thus, as was the case with the T2|T1 accuracy data, Distractor Orientation had no systematic effect on Target 1 accuracy across the range of lags usually associated with the AB.

## 2.3. Experiment 3

This experiment investigated the effects of Target 1 Orientation on the AB, in order to examine whether orientation effects arise when a stimulus is consolidated for report. Subjects were required to name two red targets, the first of which could be presented either upright or rotated by  $90^\circ$  or  $180^\circ$ , while the second one always appeared upright, as did the distractors.

### 2.3.1. T2|T1 accuracy

Fig. 4 shows the mean percentage T2|T1 accuracy as a function of Target 1 Orientation and Lag. The T2|T1 accuracy data were subjected to a  $3 \times 6$  repeated measures ANOVA with Target 1 Orientation and Lag as within-subject factors.

The main effect of Lag was significant,  $F(5, 55) = 36.67$ ,  $p < 0.0005$ . A contrast comparing performance at early lags (Lags 1 and 2, mean accuracy = 61.6%) with performance across later lags (Lags 3–6, mean accuracy = 86.95%) showed the typical AB pattern, with significantly lower accuracy at early lags,  $F(1, 11) = 173.2$ ,  $p < 0.0002$ . The main effect of Target 1 Orientation also approached significance,  $F(2, 22) = 3.07$ ,  $p = 0.066$  and there was a significant interaction between Lag and Target 1 Orientation,  $F(10, 110) = 4.11$ ,  $p < 0.0005$ . Fig. 4 shows that the AB was larger for trials where Target 1 was rotated by  $90^\circ$ , compared to trials where Target 1 was upright or rotated by  $180^\circ$ . This was confirmed by follow up comparisons, which showed that performance was lower when Target 1 was rotated by  $90^\circ$  compared to the average of  $0^\circ$  and  $180^\circ$  trials at Lags 1,  $F(1, 11) = 13.76$ ,  $p < 0.004$ , and 2,  $F(1, 11) = 15.45$ ,  $p < 0.003$ . There was no difference at these Lags between trials in which Target 1 was upright or rotated by  $180^\circ$  ( $t$ 's  $< 1$ ), indicating a similar AB in these conditions.

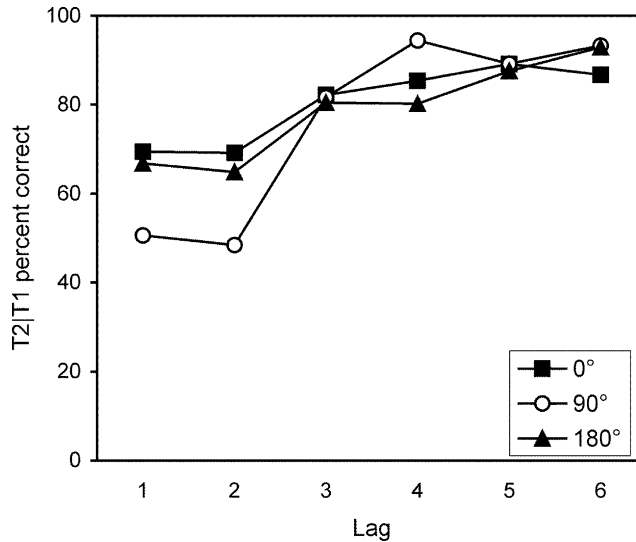


Fig. 4. T2|T1 accuracy as a function of Target 1 Orientation and Lag in Experiment 3.

### 2.3.2. T1 accuracy

The T1 accuracy data were analysed using the same  $3 \times 6$  repeated measures ANOVA. The main effect of Target 1 Orientation was significant,  $F(2, 22) = 13.2$ ,  $p < 0.0005$ . A contrast analysis revealed greater accuracy for upright trials (mean = 90.6%) compared to the average performance on trials where Target 1 was rotated by either 90° or 180° (mean = 83.4%),  $F(1, 11) = 25.7$ ,  $p < 0.0002$ . The main effect of Lag was also significant,  $F(5, 55) = 5.17$ ,  $p < 0.001$ . Subjects were more accurate across Lags 4–6 (mean = 88.2%) compared to Lags 1–3 (mean = 83.3%),  $F(1, 55) = 19.3$ ,  $p < 0.0002$ . Finally, there was a significant interaction between Target 1 Orientation and Lag,  $F(10, 110) = 8.811$ ,  $p < 0.0005$ . This was the result of performance being constant across Lags when Target 1 was upright, but more variable when Target 1 appeared upside-down or rotated by 90°.

## 3. General discussion

This study investigated whether the viewpoint costs associated with naming rotated familiar objects arise during initial identification or during a later consolidation stage. Experiment 1 tested whether initial identification of familiar objects is viewpoint-invariant or viewpoint-dependent. To do this we presented targets in their canonical view and manipulated distractor orientation. We found a robust AB under these conditions, but distractor orientation did not affect the magnitude of the blink nor did it have a systematic effect on Target 1 accuracy. We also demonstrated that

distractor orientation did not systematically influence the AB even when target objects were defined semantically, thus presumably forcing subjects to process their identities. Taken in conjunction with other evidence that distractors in RSVP streams are identified (Dux & Coltheart, 2005; Luck et al., 1996; Maki et al., 1997; Marois et al., 2004; Shapiro, Driver, Ward, & Sorensen, 1997; Vogel et al., 1998), these findings provide a lower boundary for the locus of viewpoint costs and suggest that the initial activation of stored object representations is invariant with respect to orientation in the picture plane.

In Experiment 3, we examined whether or not the orientation of Target 1 influenced the magnitude of the AB. A larger AB was found when Target 1 was rotated by 90°, compared to when it was presented upright or upside-down, but there was no difference in blink magnitude between 0° and 180° Target 1 trials. These data provide evidence that objects that are rotated by 90° require more attentional resources to be consolidated than those that are upright or upside-down.

Why might this be the case? We suggest that when an object is presented in an unfamiliar orientation, a conflict ensues between the expected familiar orientation stored in memory and the bottom-up perceptual information pertaining to the object's actual orientation. This conflict has to be resolved and a spatial reference frame established for the object, before it can be consolidated in space and time. Interestingly, the conflict between top-down and bottom-up information about the object's orientation seems to be reduced in the case of objects rotated by 180°, a result that echoes a number of our previous findings. For example, in our RB studies we found that RB is substantially alleviated, under some conditions, when one stimulus is upright and the other upside-down, suggesting that such stimuli are easier to individuate (Harris & Dux, 2005a, 2005b). Similarly, Harris, Harris, and Caine (2001) have demonstrated intact discrimination of upright vs. upside-down stimuli in a patient who was otherwise unable to interpret or discriminate object orientation. We have previously argued that this occurs because, when objects are rotated by 180°, their principal axis is aligned with the upright representation stored in memory, and this facilitates the interpretation of their orientation.

Based on these and our earlier results (Harris & Dux, 2005a, 2005b), we propose that two stages of processing are involved in the recognition of familiar objects. In stage 1, long-term representations are activated by visual input and recognition is invariant with respect to orientation in the picture plane. These initial representations are not durable, however, and require additional processing if they are to be available for report (Chun & Potter, 1995; Duncan, 1980; Neisser, 1967; Treisman & Gelade, 1980). During this subsequent processing stage, the representation is consolidated in both time and space by determining the object's orientation relative to the viewer at that particular moment.

Thus, we propose that in the case of familiar objects misoriented in the picture plane, viewpoint costs arise after the initial activation of the object's identity, as the representations are consolidated in a reportable form. As stated above, an important part of this consolidation process is placing the object (and its constituent features) in a spatial frame of reference. Although in this paper we have confined our investigation to familiar objects, it is interesting to note that similar

conclusions may be reached from research employing relatively unfamiliar and visually homogenous classes of objects rotated in the picture plane. This research has shown that viewpoint-dependent costs in recognition arise when such objects can only be distinguished by the location of their constituent features along two dimensions simultaneously (Tarr & Pinker, 1990) – that is, under conditions where a rather precise spatial analysis of the stimulus is required. In contrast, if the position of features along a single dimension uniquely identifies an object (e.g., as is the case for objects with an obvious axis of symmetry or bilateral redundancy), recognition performance tends to be orientation-invariant (McMullen & Farah, 1991; Tarr & Pinker, 1990). Furthermore, this appears to be particularly the case if the principal axis of the object has a well-defined polarity conferred by a feature located at one end of the axis (Leek & Johnston, 2006). Such findings seem to support the notion that orientation-invariant processes may be the “default” and rapid mechanism by which object constancy is achieved, *unless* the task poses a challenging spatial problem of localising the object features in a viewer-centred reference frame, along multiple axes, and maintaining this information in a reportable form. Under such conditions, performance costs associated with this spatial analysis (rather than the identification of the object features themselves, we would argue) will be apparent.

Our hypothesis that both viewpoint-invariant and viewpoint-dependent processes are involved in object recognition is in line with recent suggestions that research should focus on how these two types of representations interact during the processing of an object (Hayward, 2003).

## References

- Bülthoff, H. H., & Edelman, S. (1992). Psychophysical support for a two-dimensional view interpolation theory of object recognition. *Proceedings of the National Academy of Sciences of the United States of America*, *89*, 60–64.
- Chun, M. M. (1997). Types and tokens in visual processing: a double dissociation between the attentional blink and repetition blindness. *Journal of Experimental Psychology: Human Perception and Performance*, *23*, 738–755.
- Chun, M. M., & Potter, M. C. (1995). A two-stage model for multiple target detection in rapid serial visual presentation. *Journal of Experimental Psychology: Human Perception and Performance*, *21*, 109–127.
- Corballis, M. C. (1988). Recognition of disoriented shapes. *Psychological Review*, *95*, 115–123.
- Duncan, J. (1980). The locus of interference in the perception of simultaneous stimuli. *Psychological Review*, *87*, 272–300.
- Dux, P. E., & Coltheart, V. (2005). The meaning of the mask matters: evidence of conceptual interference in the attentional blink. *Psychological Science*, *16*, 775–779.
- Forster, K. I., & Forster, J. C. (2003). DMDX: a windows display program with millisecond accuracy. *Behaviour Research Methods, Instruments, & Computers*, *35*, 116–124.
- Grandison, T. D., Ghirardelli, T. G., & Egeth, H. E. (1997). Beyond similarity: masking of the target is sufficient to cause the attentional blink. *Perception & Psychophysics*, *59*, 266–274.
- Harris, I. M., & Dux, P. E. (2005a). Orientation-invariant object recognition: evidence from repetition blindness. *Cognition*, *95*, 73–93.
- Harris, I. M., & Dux, P. E. (2005b). Turning objects on their head: the influence of the stored axis on object individuation. *Perception & Psychophysics*, *67*, 1010–1015.

- Harris, I. M., Harris, J. A., & Caine, D. (2001). Object orientation agnosia: a failure to find the axis? *Journal of Cognitive Neuroscience*, *13*, 800–812.
- Hayward, W. G. (2003). After the viewpoint debate: where next in object recognition? *Trends in Cognitive Sciences*, *7*, 425–427.
- Jolicoeur, P. (1985). The time to name disoriented natural objects. *Memory and Cognition*, *13*, 289–303.
- Jolicoeur, P. (1990). On the role of mental rotation and feature extraction in the identification of disoriented objects: a dual-system theory. *Mind and Language*, *5*, 387–410.
- Jolicoeur, P. (1999). Concurrent response-selection demands modulate the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *25*, 1097–1113.
- Kanwisher, N. (1987). Repetition blindness: type recognition without token individuation. *Cognition*, *27*, 117–143.
- Leek, E. C., & Johnston, S. J. (2006). A polarity effect in misoriented object recognition: the role of polar features in the computation of orientation-invariant shape representation. *Visual Cognition*, *13*, 573–600.
- Luck, S. J., Vogel, E. K., & Shapiro, K. L. (1996). Word meanings can be accessed but not reported during the attentional blink. *Nature*, *383*, 616–618.
- Maki, W. S., Frigen, K., & Paulson, K. (1997). Associative priming by targets and distractors during rapid serial visual presentation: does word meaning survive the attentional blink? *Journal of Experimental Psychology: Human Perception and Performance*, *23*, 1014–1034.
- Marois, R., Yi, D.-J., & Chun, M. M. (2004). The neural fate of consciously perceived and missed events in the attentional blink. *Neuron*, *41*, 465–472.
- McLaughlin, E. N., Shore, D. I., & Klein, R. M. (2001). The attentional blink is immune to masking-induced data limits. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, *54(A)*, 169–196.
- McMullen, P. A., & Farah, M. J. (1991). Viewer-centered and object-centered representations in the recognition of naturalistic line drawings. *Psychological Science*, *2*, 275–277.
- Neisser, U. (1967). *Cognitive psychology*. Appleton-Century-Crofts: Springer.
- Olson, I. R., Chun, M. M., & Anderson, A. K. (2001). Effects of phonological length on the attentional blink for words. *Journal of Experimental Psychology: Human Perception and Performance*, *27*, 1116–1123.
- Potter, M. C. (1975). Meaning in visual search. *Science*, *187*, 965–966.
- Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: an attentional blink? *Journal of Experimental Psychology: Human Perception and Performance*, *18*, 849–860.
- Shapiro, K. L., Arnell, K. M., & Raymond, J. E. (1997). The attentional blink. *Trends in Cognitive Sciences*, *1*, 291–296.
- Shapiro, K. L., Driver, J., Ward, R., & Sorensen, R. E. (1997). Priming from the attentional blink: a failure to extract visual tokens but not visual types. *Psychological Science*, *8*, 95–100.
- Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Perception and Performance*, *6*, 174–215.
- Tarr, M. J., & Pinker, S. (1989). Mental rotation and orientation-dependence in shape recognition. *Cognitive Psychology*, *21*, 233–282.
- Tarr, M. J., & Pinker, S. (1990). When does human object recognition use a viewer-centered reference frame? *Psychological Science*, *1*, 253–256.
- Treisman, A., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology*, *12*, 97–136.
- Vogel, E. K., Luck, S. J., & Shapiro, K. L. (1998). Electrophysiological evidence for a postperceptual locus of suppression during the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 1656–1674.