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Object Naming Induces Viewpoint-Independence in Longer-Term Visual Remembering: Evidence From a Simple Object Drawing Task

Peter Walker, Helen Blake, J.Gavin Bremner

Department of Psychology

University of Lancaster, UK

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Authors Note

Correspondence concerning this article should be addressed to Peter Walker, Department of Psychology, Lancaster University, Lancaster, LA1 4YF, UK.

E-mail: P.Walker@lancaster.ac.uk

tel: +44 (0)1524 593163

Fax: +44 (0)1524 593744

Abstract

The impact of object naming on object drawing confirms an association between object categorisation and viewpoint-independence in longer-term visual remembering. Adult participants viewed a novel object from a viewpoint from which it would not normally be drawn from memory. The experimenter either labelled the object with a novel count noun ("Look at this dax") or did not ("Look at this object"). Participants then drew the object from immediate, short-term, or longer-term memory, with no constraints being imposed on how they should depict the object. When the object was named at presentation, but not otherwise, the transition from immediate to longer-term remembering increased the likelihood that the object was depicted from a viewpoint from which it had not been seen. This trend was reversed when participants were asked to depict the object in the orientation in which it had appeared to them. These results are discussed in relation to an account of the conditions under which visual category representations become established and may be used preferentially over image-like visual representations.

Object Naming Induces Viewpoint-Independence in Longer-Term Visual Remembering: Evidence From a Simple Object Drawing Task

Evidence is accumulating to suggest that short-term and longer-term visual remembering can rely on representations that preserve contrasting information about objects. For example, compared to short-term remembering, longer-term remembering is more likely to utilise visual information about object categories than about specific objects (Avons & Phillips, 1987; Burgund & Marsolek, 2000; Marsolek, 1995), and information that specifies object shape categorically rather than with metric accuracy (Rosielle & Cooper, 2001). It is less likely to utilise information about the specific viewpoints from which objects were originally seen (Biederman & Cooper, 1991, 1992; Biederman & Gerhardstein, 1993; Cooper, 1994; Cooper & Schacter, 1992; Ellis, Allport, Humphreys, & Collis, 1989; Seamon & Delgado, 1999; Seamon, Ganor-Stern et al., 1997; Stankiewicz & Hummel, 2002; Stankiewicz, Hummel, & Cooper, 1998), or visual information about the colours of objects (Brandimonte, Schooler, & Gabbino, 1997; Cooper, 1994; Hitch, Brandimonte, & Walker, 1995; Seamon et al., 1997; Walker et al., 1997).

These contrasting aspects of objects, that are differentially associated with short-term and longer-term remembering, might be preserved in two distinct types of visual representation. Candidate representations are images, such as those proposed by Tarr (e.g., Tarr, 1995), and structural descriptions, such as the geon structural descriptions (GSDs) proposed by Biederman (e.g., Biederman, 1995). Images are object-specific, preserve information about the object's orientation in depth relative to the viewer, and are likely to capture all the visible features of an object (e.g., its surface colour). In contrast, GSDs represent object categories at an intermediate level of abstraction, and focus on the shape of category relevant object parts in their spatial configuration, to the exclusion of information about an object's material properties (including colour).[1] With shape being encoded categorically, rather than with metric accuracy, GSDs are tolerant to the variation in shape among exemplars from a category. They are also largely insensitive to orientation in depth, and so can tolerate variations in the viewpoint from which an exemplar is observed. Perhaps, therefore, it is because these different forms of representation are differentially associated with short-term and longer-term remembering that information about contrasting aspects of objects has varying relevance depending on memory delay. The proposal is not that short-term and longer-term remembering are exclusively dependent on different types of representation, but rather that, though both types of representation can support visual remembering in most situations, there is a tendency for longer-term remembering to rely on GSD-like structural descriptions when these are available.

If the various features of objects associated with longer-term visual memory are preserved in a single representation, then their involvement in visual remembering should be highly correlated. For example, when participants appear to rely on visual category representations in longer-term remembering, their performance should also confirm the viewpoint-invariance of these representations. Conversely, when participants are deprived of the opportunity to rely on category representations, longer-term remembering should reveal the same sensitivity to viewpoint that is observed in short-term remembering, because in both cases viewpoint-specific object representations will mediate performance.

The experiment reported here was designed to assess this particular prediction. It did so by exploiting the impact object naming has on the creation of visual category representations. Thus, naming novel objects with novel count nouns[2] induces infants and young children to establish shape-based category representations for the objects (e.g., Baldwin, 1989; Hall, 1993; Hall & Moore, 1997; Hall, Quantz, & Persoage, 2000; Hall &

Waxman, 1993; Landau, 1994; Smith, Jones, & Landau, 1992; Waxman, 1999a; Waxman & Booth, 2001; Waxman & Hall, 1993), and it does so at an intermediate taxonomic level (Hall, 1993; Hall & Waxman, 1993; Waxman, 1999a; Waxman & Hall, 1993; Xu, Carey, & Welch, 1999).

With this evidence in mind, the potential for a three-way association between longer-term remembering, object categorisation, and viewpoint-independence was assessed by examining the impact of object naming on visual memory for a novel object at varying memory delays. It was expected that increasing evidence for viewpoint-independence would emerge with the shift from immediate to longer-term remembering, but only when the object was named, because only then would a visual category representation for the object be established.

A simple drawing task was employed to determine if object naming and memory delay combine to increase the viewpoint-independence evident in adults' drawings of a novel object from memory. Participants drew a novel object from immediate, short-term, or longer-term memory. Prior to drawing, the object was presented for inspection from a single viewpoint, at which time the experimenter either named the object with a novel count noun, or did not name it. The restricted viewpoint from which participants inspected the object was not one from which participants would normally depict the object. Depicting the object from a viewpoint other than this restricted viewpoint was to be taken as evidence for viewpoint-independence in visual remembering. No constraints were placed on how participants were to draw the object, and in particular, whether they should draw it in the orientation from which it had been seen by them (e.g., participants were simply instructed to 'Draw the dax' or 'Draw the first/second object'). It was predicted that the combined effect of naming the novel object at presentation and testing longer-term remembering, would be to increase the viewpoint-independence evident in participants' drawings, as revealed by a reduced tendency to depict the object from the restricted viewpoint from which it had been seen. Finally, to check if participants in this condition could still remember how the object had appeared to them, an additional control condition was run where participants were specifically asked to draw the object in the orientation in which it had appeared to them.

Method

Participants

One hundred and sixty one students at Lancaster University, aged between 18 and 32 years, completed the experiment. They were not paid for their participation.

Materials

Two novel objects were constructed out of wood. They each comprised an 18 cm cube, with a smaller wooden part attached to the centre of one face. For one object, the attached part was a pyramid, with an 11 cm square base and a vertex of 10 cm. For the other object, the attached part was a 7.5 cm diameter sphere.

Design

A 3x2 independent-groups design was created by crossing two factors. The factors were Memory Delay (*immediate, short-term,* and *longer-term remembering*) and Object Naming (*object named* versus *object unnamed*). An equal number of participants ($n = 23$) was assigned randomly to each of these six groups. An additional, control group of participants ($n = 23$) was assigned to a *longer-term remembering with object naming* condition, with the constraint that they should depict the object in the orientation it had appeared to them. The groups had similar mean ages and male:female ratios. For the *object named* conditions, the mean ages (in years) and male:female ratios (in parentheses) were 19.8 (5:18), 19.4 (4:19), 19.7 (6:17), and 20.3 (4:19), for the *immediate, short-term, longer-term,* and *longer-term control* conditions, respectively. The corresponding values for the *object unnamed* conditions were 19.6 (4:19), 20.4 (5:18), and 19.7 (5:18), for the *immediate, short-term,* and *longer-term* conditions, respectively. Only four of the participants drew with their left-hand (one male in each of the *immediate remembering with object naming* and *longer-term remembering with object naming* conditions, and one female in each of the *immediate remembering without object naming* and *short-term remembering without object naming* conditions).

Procedure

Each object in turn was presented for visual inspection for 20 s, and then immediately removed from sight for the remainder of the experiment (see Figure 1). In all conditions, between presentation of the two objects, participants engaged in a visual imagery task for 1 min. This was intended to ensure participants were unable to hold the first object in mind by continually visualising it (cf. Phillips, 1983, for discussion of the link between visualisation and visual memory). The imagery task was taken from Finke, Pinker, and Farah (1989), and required participants to imagine transforming and combining two letters of the alphabet to discover an emerging object. In the immediate memory condition, participants were asked to draw the second object immediately after it had been removed. In the short-term and longer-term memory conditions, after the second object had been inspected and removed from view, participants were asked to engage in the imagery task for a second time, again for 1 min. In the short-term memory condition, participants were then asked to draw the second object. In the longer-term memory condition, they were asked to draw the first object. The order of presentation of the two objects was arranged to ensure that it was always the object with the pyramid attachment that was drawn. Thus, whereas this object was the first object to be presented in the longer-term memory condition, it was the second object to be presented in the immediate and short-term memory conditions. This object was always inspected by participants from a restricted view. Specifically, the experimenter held the object in front of the participant with the attached part always pointing down. Previous research has shown that this is rarely an orientation in which this type of object will be drawn after it has been seen from all major viewpoints (cf., Walker et al., 2006). Viewing of the other object was unrestricted, with the experimenter rotating the object in front of the participant following a carefully rehearsed routine that exposed the object equally from every major viewpoint. Participants did not know in advance which object they would be asked to draw, or how they would be asked to draw it. In the *object named* condition, as the experimenter presented each object for inspection, she named it using one of two novel count nouns (i.e., “This is a riff/dax. Please look at this riff/dax.”) A different label was assigned to the two objects. When later requesting participants in this condition to draw one of the objects, she said “Do you remember the first/second object? It was a riff/dax. Please now draw it for me.” In the *object unnamed* condition, as the experimenter presented each object for inspection, she said “This is an object. Please look at this object.” When later requesting participants in this condition to draw one of the objects, she said “Do you remember the first/second object? Please now draw the first/second object for me.” In the additional control condition, which combined longer-term remembering and object naming, the experimenter requested participants to draw the first object in the orientation in which it had appeared to them, saying “Do you remember the first object? It was a riff/dax. Please now draw it for me in the orientation in which it had appeared to you.”

Results

The view from which the object was depicted in each drawing was assessed by a colleague who was ignorant of the purpose of the study and of the conditions under which each drawing had been produced. In every case, it was clear that the attached part had been including in the drawing, and in which direction the object (i.e, the attached part) was pointing.

Figure 2 presents the number of drawings in each condition where the object was depicted either from the restricted viewpoint from which it had been seen, or from some other viewpoint. For all statistical analyses, an alpha level of .05 was adopted.

Changes in the likelihood of depicting the object from the restricted viewpoint, versus some other viewpoint, confirmed the combined impact of object naming and memory delay. Aggregating across levels of memory delay, there were significantly more drawings in the *object named* condition, than in the *object unnamed* condition, that depicted the object from a viewpoint other than the one from which it had been seen, *Fisher's Exact* $p = .002$. In the *object unnamed* condition, the likelihood of depicting the object from the restricted viewpoint did not change as memory delay was extended, *Linear-by-Linear Association* $(1, N = 69) = 0.76$, $p = .385$. In the *object named* condition, the likelihood of depicting the object from the restricted viewpoint decreased as memory delay was extended, *Linear-by-Linear Association* $(1, N = 69) = 21.25$, $p < .001$. Two separate analyses of the results from the *object named* condition confirmed that the likelihood of depicting the object from the restricted viewpoint decreased significantly with both the transition from immediate to short-term remembering, *Fisher's Exact* $p = .023$, and with the transition from short-term to longer-term remembering, *Fisher's Exact* $p = .009$. Neither of these transitions had a significant impact in the *object unnamed* condition, *Fisher's Exact* $p = .61$ and .19, for the immediate to short-term and short-term to longer-term transitions, respectively.

The results from the longer-term remembering control condition were clear. Despite having heard the experimenter name the object, all the participants drew the object in the orientation in which it had appeared to them.

Discussion

The results confirm that with the transition from immediate to longer-term remembering, object naming reduces the likelihood that participants will be constrained to depict a remembered object from the viewpoint from which it had been seen. Given the evidence linking object naming with object categorisation, this result is consistent with the proposal that two distinct types of visual representation are differentially associated with short-term and longer-term remembering. More specifically, though both image-like and GSD-like representations can support remembering across a full range of circumstances, there is a tendency for longer-term remembering to utilise GSD-like representations when these are available. Object naming can be a critical factor determining the availability of GSD-like representations and, because of this, the extent to which visual remembering is viewpoint-independent.[3]

Walker et al. (2006) also have shown that naming a similar novel object (a cube with a cone attachment) with a novel count noun can impact on young children's drawings of the object. In their study, however, the object remained available for inspection during drawing. Specifically, after it had been shown to the children from every major angle, it was placed in position for drawing with the cone hidden from view (i.e., pointing directly away from the children). It is known that young children are inclined to depict an object part that is currently hidden from view (e.g., Freeman & Janikoun, 1972), and such intellectual realism can be seen as another example of viewpoint-independence in drawing. It is relevant to note, therefore, that Walker et al. confirmed that if the object was labelled with a novel count noun as it was being inspected prior to drawing, the likelihood that the children would be constrained by the viewpoint from which they could see the object was reduced. When the object was named, the children showed an increased tendency to depict the object from a viewpoint that revealed the hidden part, but only if the name chosen indicated that this part was category relevant. In the present context, these results confirm that, despite their differential association with longer-term remembering, visual object category representations can impact on live drawing (i.e., drawing an object that remains available for inspection). It seems, therefore, that when young children engage in live drawing, they behave as if they were adults drawing from longer-term visual memory.

According to the current proposal, whenever a task requires participants to refer to those aspects of an object that are best preserved in an image-like representation, object naming will have the potential to impact negatively on performance, especially if this involves longer-term, rather than short-term, remembering. The task might require participants to draw an object from its current viewpoint, or from the viewpoint from which it was last seen. Alternatively, it might require them to reproduce the colour and shape of the object with high fidelity.

Detrimental effects of object naming on longer-term visual remembering have already been demonstrated in studies of visual image combination (cf. Brandimonte, Hitch, & Bishop, 1992; Hitch, Brandimonte, & Walker, 1995; Walker et al., 1997). In these studies, participants were asked to combine a visual image of a recently presented line drawing with an image of a current line drawing. They were then to discover the identity of the object resulting from this combination. The nature of the to-be-combined drawings required the superimposition of the two images in the mind’s eye to be metrically accurate. In some situations, the recently presented visual stimulus was either still available in short-term memory (because no other item had been presented in the interim), or it was available only in longer-term memory (because other task-relevant items had been presented in the interim). In addition, it was arranged that when the memory item depicted a familiar object, it was either named or unnamed at presentation. In agreement with the results of the present study, participants were *less* able to complete the image combination task if the object depicted in the first drawing was named at presentation. Moreover, this detrimental effect of naming was observed only with longer-term remembering, and not with short-term remembering. Walker et al. (1997) proposed that performance was impaired by object naming because this induced participants to increase their reliance on a visual representation of the category to which the object belonged, with the effect that the shape of the object became less accurately described (i.e., there was a shift towards shape being described categorically rather than with metric accuracy). Finally, additional support for the current proposal emerged with the observation that performance in the image combination task was insensitive to the colour congruity of the to-be-combined stimuli, but only when longer-term remembering was being assessed and the first figure had been named (Hitch, Brandimonte, & Walker, 1995; Walker et al., 1997). With short-term remembering, image combination was impaired when the two figures to be combined appeared in different colours (e.g., black-on-grey and white-on-grey), rather than the same colour (e.g., both black-on-grey), regardless of whether or not the first figure was named. In other words, whereas the visual representation supporting longer-term remembering resembled a GSD-like representation insofar as it did not preserve object colour, the visual representation supporting short-term remembering resembled an image-like representation insofar as it preserved object colour independently of object naming.

Much of the evidence confirming the impact of distinct types of visual representation in longer-term remembering has involved the contrast between implicit and explicit tests of memory (see, for example, Cooper, 1994, and Srinivas, 1996). For example, though longer-term priming in both object naming and the possible-impossible object decision task has been shown to involve visual representations that do not preserve information about viewpoint and object colour, explicit recognition memory for the same stimuli has been shown to involve visual representations that do preserve information about these two features (Biederman & Cooper, 1991, 1992; Cooper, 1994; Cooper & Schacter, 1992; Seamon & Delgado, 1999; Seamon et al., 1997; Srinivas, 1996). Clearly, therefore, a full account of the representational basis of visual remembering, and of the moderating influence of object naming, will need to acknowledge the distinction between implicit and explicit tests of memory. Nevertheless, the present results confirm that, as an explicit test of memory, object drawing tasks can reveal the varying contributions of different types of visual representation and the moderating influence of object naming.[4]

Figure 3 illustrates the conceptual framework developed here to accommodate the results of the present study and related findings (e.g., Hitch, Brandimonte & Walker, 1995; Walker et al., 1997). It is proposed that when an object is encountered, distinct visual processes support the derivation of the two types of visual representation. These are labelled simply as type A and type B processes, so as to remain mute regarding their nature.[5] It is assumed that image-like visual representations are always established, whereas certain conditions have to be satisfied for a visual category representation to be established. Combining object naming (i.e., naming a novel object with a novel count noun in the present study) with longer-term remembering creates a sufficient condition for this to occur. These two component conditions are seen to impact on different aspects of the cognitive resources supporting object drawing. Whereas object naming facilitates the derivation of a visual category representation, longer-term remembering increases the likelihood that this representation will be used to support performance. Neither of these component conditions is thought to be *necessary* for a category representation to impact on performance. Indeed, Biederman and Bar (1999) and Coltheart, Mondy, and Coltheart (2005) have revealed that, on the basis of encountering a single view of a novel object, a viewpoint-independent visual representation can be established quickly, even in the absence of object naming. And in their studies of viewpoint-independent visual priming in the possible-impossible object decision task, Schacter and Cooper have revealed a number of visual encoding conditions, other than object naming, that lead to the derivation of viewpoint-independent structural descriptions of novel objects (e.g., deciding if a novel object depicted in a simple line drawing faces left or right, deciding how the object might be used as a tool, or deciding if the object resembles an item of household furniture) (Schacter & Cooper, 1993; Schacter, Cooper, & Delaney, 1990). Schacter and Cooper argue that the need to derive a global structural description of the novel object is common to all encoding conditions yielding viewpoint-independent visual priming.

It is proposed that image-like representation(s) do not become unavailable or inaccessible when a visual category representation is established. Indeed, even when naming was combined with longer-term remembering in the control condition of the present study, participants were able to draw the critical object in the restricted viewpoint from which it had been seen when asked to do so. Brandimonte, Schooler, and Gabbino (1997) also have shown that the detrimental effects of object naming in longer-term visual remembering can be reversed by providing colour as a visual cue to facilitate access to the original visual representation. And in an earlier study of verbal overshadowing, Schooler and Engstler-Schooler (1990) demonstrated that requiring participants to make their face recognition judgements quickly removed the verbal overshadowing effect, confirming that the original visual representation of the face had not been eradicated when participants provided a verbal description of the face. Finally, Schacter and colleagues (e.g., Cooper & Schacter, 1992; Schacter & Cooper, 1993; Schacter, Cooper & Delaney, 1990) and Burgund and Marsolek (2000) have confirmed that viewpoint-specific and viewpoint-independent visual representations can co-exist in memory, and that particular task conditions can determine which type of representation impacts on performance (e.g., whether the test stimulus is presented directly to the left or right cerebral hemisphere).

Although the focus has been on viewpoint in the present study, the conceptual framework being proposed implies that other visual features will correlate with object naming and longer-term remembering. It is predicted that whenever conditions are such as to encourage the drawer to rely on an image-like representation, their drawings will be more likely to reflect object shape with metric accuracy, and to reproduce the object's material properties (e.g., surface texture and colour). Conversely, these features will be less apparent when conditions are such as to encourage the drawer to rely on a GSD. Further work is required to assess these predictions, and to see if these other features of drawings will co-occur with viewpoint-dependence.

When a person names a *familiar* object with its category label, they are required to categorise the object visually, and in many situations this in turn will require them to derive a structural description. But why should hearing someone else name a novel object with a novel count noun induce a person to visually categorise the object? That it should do so is often assumed in discussions of language acquisition. According to Waxman (1999), for example, object naming by someone else (typically by an adult, who also gestures towards the object) is perceived by young children to be an act of object categorisation, encouraging the children themselves to categorise the object. In this way, children learn to associate a visual representation of the object's category with a verbal representation of the name provided by the adult, which typically is the name of the object's category. The claim being made here is that these processes, which are so important in early language development, remain influential in later life. Thus, just like young children, adults who hear an experimenter name a novel object with a novel count noun also perceive the experimenter to be categorising the object and also, therefore, are induced to derive a visual category representation for the object. On this account, verbal recoding has a significant impact on visual information processing, including visual remembering, even when it is someone else who is heard to do the verbal recoding.

Verbal overshadowing. Much of the work on verbal overshadowing has focused on using faces as stimuli, has required participants to provide verbal descriptions of the faces, and has then examined the impact of this on explicit, forced-choice visual recognition memory for the faces. Of course, providing a verbal description of an item is not the same as naming it, and faces are a distinct class of stimuli with distinct systems of visual categorisation. Despite these differences, however, it is worth reflecting on some implications of the conceptual framework presented here for studies of verbal overshadowing.

The first point to make is that because distinct forms of visual processing support the derivation of distinct types of representation, the present conceptualisation allows either the type of encoding, or the type of representation, to be emphasised in accounts of verbal overshadowing. That is, explanations of overshadowing based on representational competition (e.g., Schooler & Engstler-Schooler, 1990) are not incompatible with explanations based on the transfer of inappropriate processing (e.g., Schooler, 2002).

A second point to make relates to the fact that early accounts of verbal overshadowing emphasise the contrast between verbal and visual representations of the same item, and how the relative utility of these forms of representation varies according to context. Accordingly, these accounts require that the foils for the recognition test are selected carefully, so that it is clear if, and to what extent, recognition can be supported by verbal representations. If it cannot, because the target and foils share similar verbal descriptions, then any verbal overshadowing that occurs will have to be explained without reference to the availability/accessibility of verbal representations. The present conceptualisation indicates that it is also important to know the extent to which visual recognition can be supported by visual category representations, and again the nature of the foils is critically important. To give one example, if all the foils were to share the same basic geon structural description as the target, then visual category representations would be precluded from supporting visual recognition memory, which instead would have to rely exclusively on visual representations that are capable of discriminating among examplars from the same visual category (i.e., rely on visual images).

Studies of the impact of verbal recoding on visual image manipulation were designed to preclude verbal representations from mediating performance, so that interest could be focussed on alternative forms of visual representation and their differential association with object naming and memory delay (see, for example, Hitch et al., 1995, & Walker et al., 1997). But is performance in the current object drawing task supported exclusively by visual memory representations, or can verbal representations make a contribution? In principle, verbal representations have the potential to support object drawing. However, it is important to note that the novel count noun assigned to the object participants in the present study had to draw carried no information about the nature of the object, and so could not contribute directly to drawing.

A final point to make is that unconstrained verbal descriptions can include the names of different types of visual category to which an item belongs, although they need not.

Indeed, in some studies of verbal overshadowing, participants have been instructed to include category labels in their descriptions (e.g., personality type, occupational category, age group, gender, weight category, and hair colour). However, control over the inclusion of category labels is not normally exercised, nor are the foils for the recognition test selected with the potential utility of category representations in mind. Uncertainty often remains, therefore, regarding the involvement of category representations in supporting visual recognition memory. From a purely procedural point of view, therefore, the present conceptual framework, and the success of the present study, indicates that there might be considerable merit in providing participants with a verbal description, rather than asking them to generate their own. The fact that the description is provided by someone else might not be critical, allowing control to be exercised over the nature of the verbal description that might lead to verbal overshadowing.

References

Avons, S. E., & Phillips, W. A. (1987). Representation of matrix patterns in long- and short-term visual memory. *Acta Psychologica, 65,* 227-246.

Baldwin, D. A. (1989). Priorities in children's expectations about object label reference: Form over colour. *Child Development, 60,* 1291-1306.

Biederman, I. (1995). Visual object recognition. In S.M. Kosslyn and D.N. Osherson (Eds) *Visual Cognition: An invitation to Cognitive Science. Second Edition. Volume 2.* Cambridge, Mass: MIT Press.

Biederman, I. & Bar, M. (1999). One-shot viewpoint invariance in matching novel objects. *Vision Research, 39,* 2885-2899.

Biederman, I. & Cooper, E. E. (1991). Evidence for complete translational and reflectional invariance in visual object priming. *Perception, 20,* 585-593.

Biederman, I. & Cooper, E. E. (1992). Size invariance in visual object priming. *Journal of Experimental Psychology: Human Perception and Performance, 18,* 121-133.

Biederman, I., & Gerhardstein, P. C. (1993). Recognizing depth-rotated objects: Evidence and conditions for 3D viewpoint invariance. *Journal of Experimental Psychology: Human Perception and Performance, 19,* 1162-1182.

Bozeat, S., Lambon Ralph, M. A., Graham, K. S., Patterson, K., Wilkin, H., Rowland, J., Rogers, T. T., & Hodges, J. R. (2003). A duck with four legs: Investigating the structure of conceptual knowledge using picture drawing in semantic dementia. *Cognitive Neuropsychology, 20,* 27-47.

Brandimonte, M.A., Hitch, G.J., & Bishop, D.V.M. (1992). Influence of short-term memory codes on visual image processing: Evidence from image transformation tasks. *Journal of Experimental Psychology: Learning, Memory & Cognition, 18,* 157-165.

Brandimonte, M.A., Schooler, J.W., & Gabbino, P. (1997). Attenuating verbal overshadowing through visual retrieval cues. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 915-931.

Burgund, E.D. & Marsolek, C.J. (2000). Viewpoint-invariant and viewpoint-dependent object recognition in dissociable neural subsystems. *Psychonomic Bulletin and Review, 7,* 480-489.

Coltheart, V., Mondy, S., & Coltheart, M. (2005). Repetition blindness for novel objects. *Visual Cognition, 12,* 519-540.

Cooper, L. A. (1994). Probing the nature of the mental representation of visual objects: Evidence from cognitive dissociations. In S. Ballesteros (Ed.), *Cognitive approaches to human perception.* Lawrence Erlbaum Associates: Hillsdale, New Jersey.

Cooper, L. A., & Schacter, D. L. (1992). Dissociations between structural and episodic representations of visual objects. *Current Directions in Psychological Science, 1,* 141-146.

Ellis, R., Allport, D.A., Humphreys, G.W., & Collis, J. (1989). Varieties of object constancy. *Quarterly Journal of Experimental Psychology, 41,* 775-796.

Finke, R. A., Pinker, S., & Farah, M. J. (1989). Reinterpreting visual patterns in mental imagery. *Cognitive Science, 13,* 51-78.

Freeman, N. H., & Janikoun, R. (1972). Intellectual realism in children's drawings of a familiar object with distinctive features. *Child Development, 43,* 1116-1121.

Hall, D. G. (1993). Basic-level individuals. *Cognition, 48,* 199-221.

Hall, D. G. & Moore, C. E. (1997). Red Bluebirds and Black Greenflies: Preschoolers' understanding of the semantics of adjectives and count nouns. *Journal of Experimental Child Psychology, 67,* 236-267.

Hall, D. G., Quantz, D. H., & Persoage, K. A. (2000). Preschoolers' use of form class cues in word learning. *Developmental Psychology, 36,* 449-462.

Hall, D. G. & Waxman, S. R. (1993). Assumptions about word meaning: Individuation and basic-level kinds. *Child Development, 64,* 1550-1570.

Hitch, G.J., Brandimonte, M.A., & Walker, P. (1995) Two types of representation in visual memory: Evidence from the effects of stimulus contrast on image combination. *Memory & Cognition, 23,* 147-154.

Landau, B. (1994). Object shape, object name, and object kind: Representation and development. *The Psychology of Learning and Motivation, 31,* 253-304.

Marsolek, C.J. (1995). Abstract visual-form representations in the left cerebral hemisphere. *Journal of Experimental Psychology: Human Perception and Performance, 21,* 375-386.

Phillips, W. A. (1983). Short-term visual memory. *Philosophical transactions of the Royal Society of London, Series B, 302,* 295-309.

Rosielle, L. J., & Cooper, E. E. (2001). Categorical perception of relative orientation in visual object recognition. *Memory and Cognition, 29,* 68-82.

Schacter, D. L. & Cooper, L. A. (1993). Implicit and explicit memory for novel visual objects: Stucture and function. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 995-1009.

Schacter, D. L., Cooper, L. A., & Delaney, S. M. (1990). Implicit memory for unfamiliar objects depends on access to structural descriptions. *Journal of Experimental Psychology: General, 119,* 5-24.

Schooler, J. W. (2002). Verbalization produces a transfer inappropriate processing shift. *Applied Cognitive Psychology, 16,* 989-997.

Schooler, J. W., & Engstler-Schooler, T. Y. (1990). Verbal overshadowing of visual memories: Some things are better left unsaid. *Cognitive Psychology, 22,* 36-71.

Seamon, J. G. & Delgado, M. R. (1999). Recognition memory and affective preference for depth-rotated solid objects: Part-based structural descriptions may underlie the mere exposure effect. *Visual Cognition, 6,* 145-64.

Seamon, J. G., Ganor-Stern, D., Crawley, M. J., Wilson, S. M., Weber, W. J., O'Rourke, C. M., & Mahoney, J. K. (1997). A mere exposure effect for transformed three-dimensional objects. Effects of reflection, size, or color changes on affect and recognition. *Memory and Cognition, 25,* 367-374.

Smith, L. B., Jones, S. S., & Landau, B. (1992). Count nouns, adjectives, and perceptual properties in children's novel word interpretations. *Developmental Psychology, 28,* 273-286.

Srinivas, K. (1996). Contrast and illumination effects on explicit and implicit measures of memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* 1123-1135.

Stankiewicz, B.J. & Hummel, J.E. (2002). Automatic priming for translation- and scale-invariant representations of object shape. *Visual Cognition, 9,* 719-739.

Stankiewicz, B.J., Hummel, J.E., & Cooper, E.E. (1998). The role of attention in priming left-right reflections of object images: Evidence for a dual representation of object shape. *Journal of Experimental Psychology: Human Perception and Performance, 24,* 732-744.

Tarr (1995). Rotating objects to recognize them: A case study on the role of viewpoint dependency in the recognition of three-dimensional objects. *Psychonomic Bulletin and Review, 2,* 55-82.

Walker, P., Bremner, J.G., Merrick, K., Coates, S., Cooper, E., Lawley, R., Sageman, R., & Simm, R. (2006). Visual mental representations supporting object drawing: How naming a novel object with a novel count noun impacts on young children's object drawing. *Visual Cognition, 13,* 733-788.

Walker, P., Hitch, G.J., Dewhurst, S.A., Whiteley, H.E., & Brandimonte, M.A. (1997). The representation of nonstructural information in visual memory: Evidence from image combination. *Memory and Cognition, 25,* 484-491.

Waxman, S. R. (1999). The dubbing ceremony revisited: Object naming and categorization in infancy and early childhood. In D. L. Medin & S. Atran (Eds.), *Folkbiology* (pp. 233-284). Cambridge, MA: Bradford.

Waxman, S. R. & Booth, A. E. (2001) Seeing pink elephants: Fourteen-month-olds' interpretations of novel nouns and adjectives. *Cognitive Psychology, 43,* 217-242.

Waxman, S. R. & Hall, D. G. (1993). The development of a linkage between count nouns and object categories: Evidence from 15- to 21-month-old infants. *Child Development, 64,* 1224-1241.

Xu, F., Carey, S., & Welch, J. (1999). Infants' ability to use object kind information for object individuation. *Cognition, 70,* 137-166.

Footnotes

1 As a referee has correctly pointed out, a GSD could have an associative link to a representation of the typical colour for a category of object, and evidence from neuropsychology indicates this to be the case. However, notwithstanding the presence of such links, structural descriptions and colour will still be separately represented, allowing stored information about structure to be accessed selectively, without information about colour being accessed at the same time. Our argument is that the same selectivity is not an option when images are accessed, because images do not represent structure and colour separately, but rather in an integrated manner. In addition, of course, many object categories, especially artefacts, do not have a typical colour, so their GSDs will not be linked to representations of colour.

2 A count noun is a noun for a single entity, including objects *(lamp)* and mental entities *(image)*, that can be counted. Hence, count nouns appear with indefinite articles in phrases refering to a single instance of a type of entity (*a lamp*), and in phrases refering to multiple instances of a type of entity (*six lamps*, *many images*).

3 With regard to why, when an orientation has to be specified for a category of object, certain orientations become preferred, we presume there are many contributing factors. Frequency of exposure to particular orientations would be the most obvious, though this cannot apply here. The ease with which the constituent geons can be discriminated from a particular orientation is claimed to be another factor. In addition, as a referee pointed out, the stability of an object in a particular orientation is likely to be another factor, in part because an unstable orientation is an unlikely orientation from which to encounter the same type of object in the future. Having said this, however, we might note the overwhelming tendency for people to draw bicycles in an unstable orientation (i.e., upright, and with no apparent support

being depicted). The functional significance of certain orientations also is likely to be very important. Thus, drinking mugs can only serve their usual function from a limited range of orientations, and they normally do this best when their handles are pointing to the viewer's right (so that a right-handed person can grasp the mug easily). We intend to run a study in which we explain an intended function for our novel object. In one condition, this function will require the object to be oriented with the attached part pointing down (e.g., so that indentations can be made in pastry). We then expect this orientation to become the preferred one, and the one towards which drawers will shift when object naming is combined with longer-term remembering.

4 A good illustration that object drawing can reveal the varying contributions of different types of visual representation according to memory delay is provided by a Bozeat et al. (2003). They presented geometric designs and pictures of familiar objects to patients with semantic dementia. They asked the patients either to copy the pictures, or to draw them some time after they had been removed from view. With regard to the pictures of familiar objects, the patients produced good copies, but their drawings after a delay were much less good. In addition, the quality of an individual patient's delayed drawings was correlated with the severity of their dementia, and with the quality of the drawings they produced of the same objects in response to being given their names. There was no unusual deterioration with delay in their drawings of the geometric designs. The point to note in the context of the present study is that whereas immediate object drawing was uninfluenced by category representations in long-term memory, and hence by the dementia, delayed object drawing was.

5 It is beyond the scope of the present paper to explore either the nature of the processes required to derive each type of visual representation, or the interdependencies between them. Though they are likely to share very early visual encoding pathways, it is not clear at what

point they dissociate. It is also unclear if the processes dissociate to operate in parallel of each other, as illustrated in Figure 3, or if the processes responsible for deriving a viewpoint-independent structural description follow in sequence those responsible for deriving the corresponding viewpoint-specific image(s).

Figure Captions

Figure 1. The sequence of visual events in each memory condition.

Figure 2. The number of participants depicting the novel object from the restricted viewpoint from which it had been seen, or from some other viewpoint, as a function of whether or not the object was named with a novel count noun at encoding, and according to whether it was drawn from immediate memory (IMM), short-term memory (STM), or longer-term memory (LTM).

Figure 3. The conceptual framework developed to accommodate the results of the present study and related findings. The information provided by the two types of visual representation is depicted as converging on common production mechanisms. This is intended to reflect the fact that a single drawing need not be based exclusively on one type of representation, but can be based on a mix of representations, including viewpoint-specific object representations and category representations (for evidence, see Walker et al., 2006).

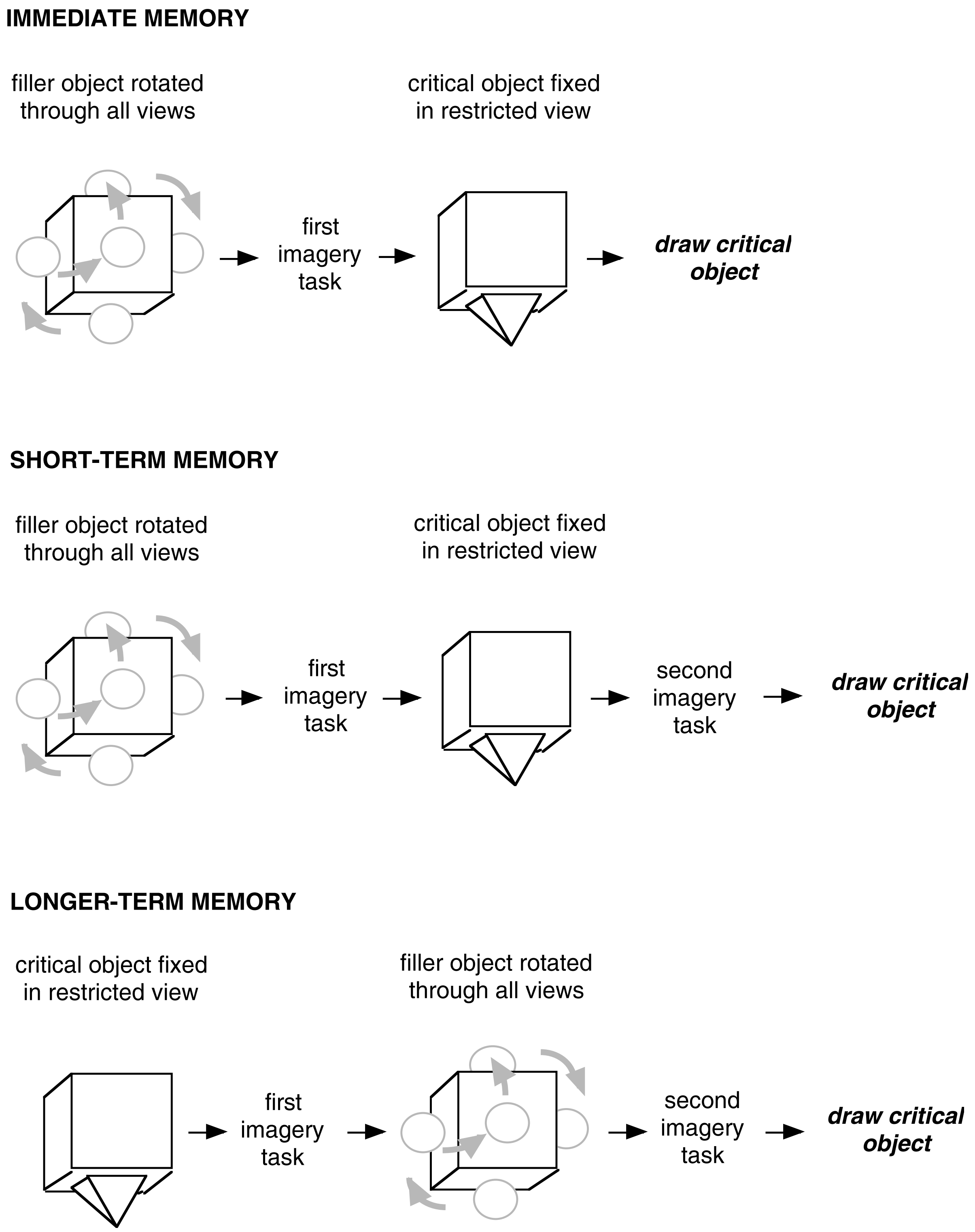

IMMEDIATE MEMORY
filler object rotated
through all views
first
imagery
task
critical object fixed
in restricted view
draw critical
object
SHORT-TERM MEMORY
filler object rotated
through all views
first
imagery
task
critical object fixed
in restricted view
second
imagery
task
draw critical
object
LONGER-TERM MEMORY
critical object fixed
in restricted view
first
imagery
task
filler object rotated
through all views
second
imagery
task
draw critical
object

Figure 1

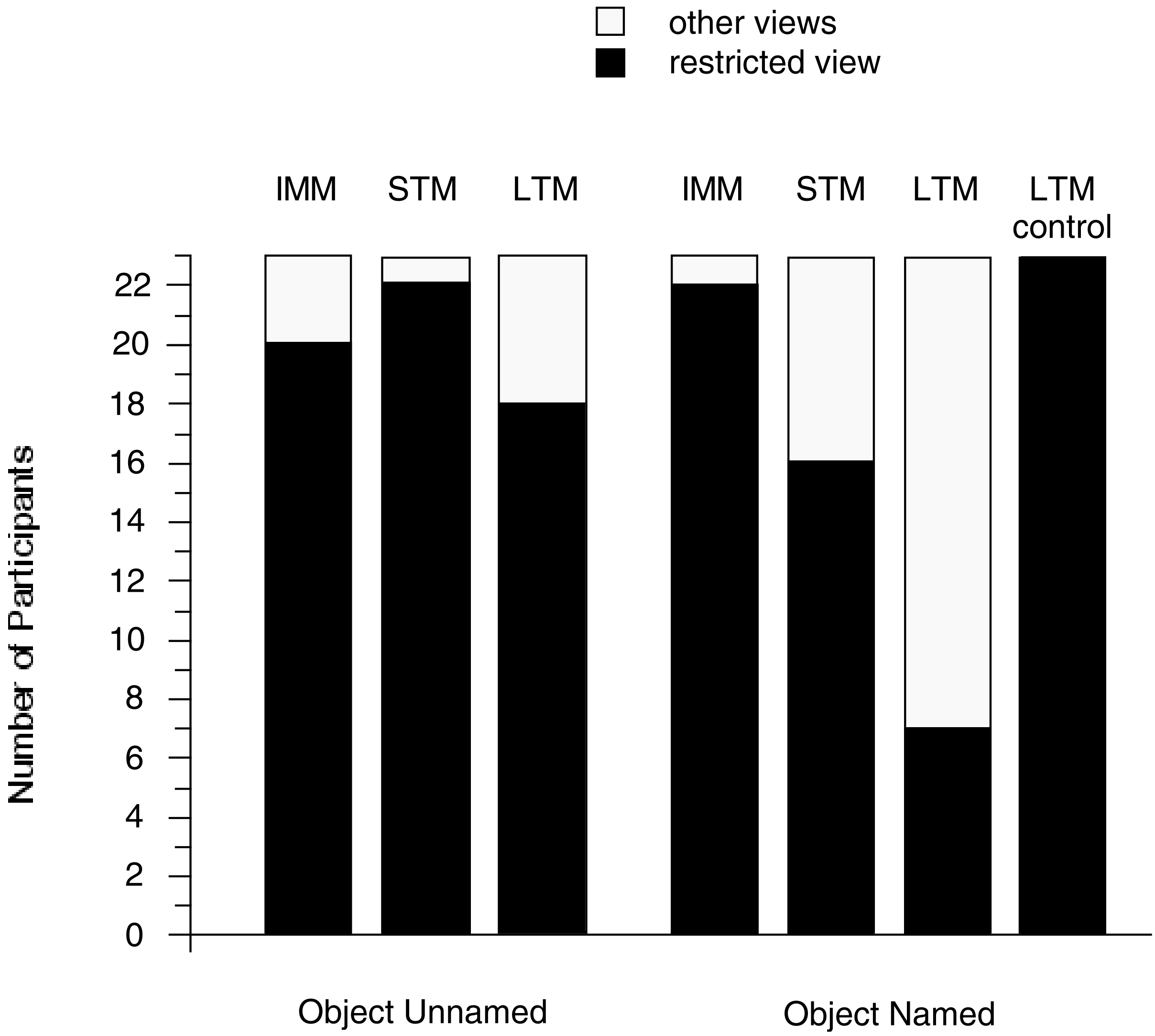
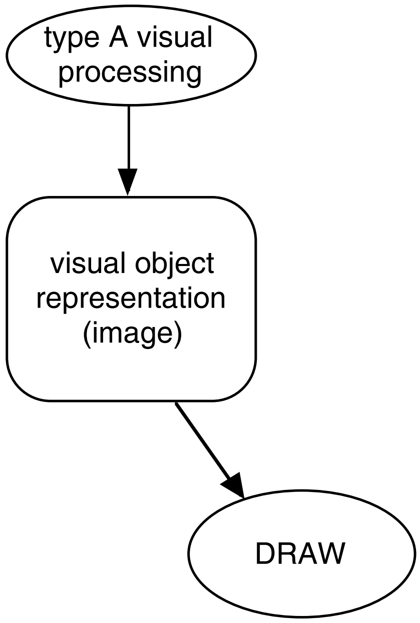

other views
restricted view
IMM
STM
LTM
IMM
STM
LTM
LTM control
Number of Participants
0
2
4
6
8
10
12
14
16
18
20
22
Object Unnamed
Object Named

Figure 2

WITHOUT OBJECT NAMING



WITH OBJECT NAMING

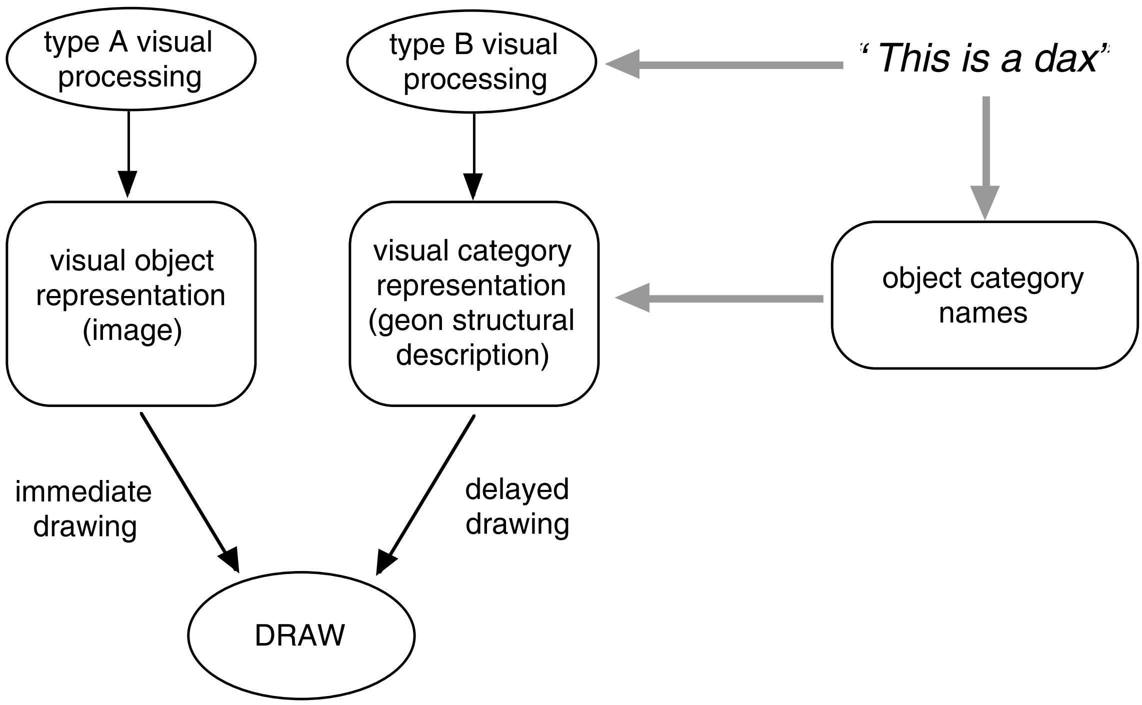


Figure 3