

## Chapter 13

### Young children's use of color information during language-vision mapping

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#### Introduction

Color vision is the "capacity to discriminate among stimuli that differ in wavelength composition, on the basis of the difference in wavelength composition alone" (Teller, 1998, p. 3281). There is plenty of evidence that 2 month old infants can respond to high contrast red/green chromatic differences (e.g., Peeples & Teller, 1975). 4-month-olds habituate after viewing a color for sometime and look away, and then look again when shown a color from a different universal category but not when shown a new color from the same category (Özgen, 2004). Thus, color discrimination abilities appear to be present very early in infancy.

Reports about children's apparent difficulty in *naming* colors however are abundant in the developmental literature. Wolfe (1890) found that there was no color word among the first 300 to 500 words that infants possess. Modreski and Goss (1969) found that 3 to 5 year old children have a better knowledge of form names than of color names. According to Bornstein (1985b), Darwin (1877) reported: "I carefully followed the mental development of my small children, and I was astonished to observe in two or, as I rather think, three of these children, soon after they

had reached the age in which they knew the names of all the ordinary things that they appeared to be entirely incapable of giving the right names to the colors of a color etching. They could not name the colors, although I tried repeatedly to teach them the names of the colors. I remember quite clearly to have stated that they are color blind. But afterwards this turned out to be an ungrounded apprehension" (p. 74). Consistent with Darwin's anecdotal reports, Davidoff and Mitchell (1993) found that 3- and 4-year-olds perform very poorly if asked to point to the correctly colored object when shown an appropriately colored option and an inappropriately colored one. Davidoff and Mitchell (1993) reported that one of the children they tested commented on Father Christmas when coloring: "This is Father Christmas, he wears a red coat" and then proceeded to color the line drawing in green (p. 135). Nagel (1906) even coined the term "Farbendummheit" ('color stupidity') for early childhood. Bornstein (1985a) found that in a shape-name and color-name association study in which 3-year-olds were asked to learn paired associates of arbitrary proper names, the children performed much better for shape-name pairs than color-name pairs.

Bornstein (1985b) summarized the literature as revealing that "(i) even young infants perceive colors accurately, that is, discriminate, match, and categorize colors; (ii) young children recognize that color is a separate domain of experience and readily identify it as such, and so the question, "what color is this"?, regularly elicits a color term (though infrequently not among the very youngest children); and, (iii) children know different color words. However, (iv) children's color identification is immature in that they reply with incorrect names to colors they see or pick incorrect colors for names they hear; (v) there seems to be a lower age bound for mature color naming that hovers around 4 years" (p.78). Bornstein (1985b) concluded that "early in life, sensory and linguistic color knowledge seem to coexist, but a proper map connecting names and

perception is late in developing" (p.78).

In the present chapter I will describe some recent eye-tracking studies which contradict this conclusion. This more recent research reveals that although (at least some) young children struggle with explicit color knowledge, their implicit object color knowledge in fact is fairly advanced. This research shows that even young children's mapping between linguistic and visual representations is mediated by color knowledge. Perceptual-conceptual knowledge about typical object color can determine toddlers' language-mediated eye gaze behavior even before they have mastered to link color words with the appropriate colors.

Understanding how young children use color information during online word-object mapping is important for our larger understanding of the development of cognition. It reveals how developing higher order cognitive (e.g., linguistic) representations interact with the developing mechanisms underlying visual attention and perceptual processing, something which we know surprisingly little about. Before describing the relevant developmental studies I will review related research on language-vision mapping with adult participants.

### **Background: Past research on adult language-vision mapping**

How mature language users integrate lexical information retrieved during spoken language processing (e.g., knowledge about semantic and visual properties of a word's referent) with information retrieved from the visual environment (e.g., the semantic and visual properties of co-present visual objects) to guide their eye gaze has recently attracted great interest. In an early study, Roger Cooper (1974) observed that there is a tight link between spoken language processing and eye gaze to objects in the concurrent visual environment (see also Tanenhaus et al., 1995). His participants listened to short narratives (e.g., a story about a safari in Africa) while their eye movements were monitored on an array of spatially distinct line drawings of common

objects, some of which were referred to in the spoken sentences. Cooper observed that his participants very quickly shifted their eye gaze to objects which were referred to, often already during the acoustic duration of the respective word (e.g., half way during the acoustic unfolding of the word 'lion' participants started to shift their overt attention to the line drawing of the lion). Cooper also noticed that semantically related objects attracted increased overt attention (e.g., on hearing 'Africa' participants were more likely to look at a snake, a lion, and a zebra than semantically unrelated objects). Though Cooper recognized the potential of the new experimental technique 'for the real-time investigation of perceptual and cognitive processes' (p.84) he did not use the method to explore these issues any further. Only recently has the mapping of language-derived and vision-derived representations begun to be explored in a systematic manner. To understand how (e.g. color) representations are mapped (by both adults and children) it is necessary to determine what and when different types of representations are retrieved from both systems.

Recent research with adult participants has shown that individuals establish matches at phonological (Allopenna et al., 1998), semantic (Huettig & Altmann 2005, Yee & Sedivy, 2006), and visual (shape: Dahan & Tanenhaus, 2005, Huettig & Altmann, 2004, 2007; color: Huettig & Altmann, 2004, 2011) levels of processing between information retrieved from the spoken words and from the visual surroundings (see Huettig, Rommers, & Meyer, 2011, for review).

Shifts in eye gaze based on a (partial) *phonological* match between spoken word (e.g., 'beaker') and visual object (e.g., a beaver; both beaker and beaver are phonologically similar at word onset) depend crucially on the amount of time participants have to inspect the visual scene. If participants have sufficient time to inspect the scene (e.g., 2 or 3 seconds for a simple display of four objects) they appear to be able to make use of a match between the phonological

information retrieved from the speech signal and the phonological information retrieved from the object (i.e. the object's name; Huettig & McQueen, 2007, Experiment 1). If participants have insufficient time (e.g., 200 ms, Huettig & McQueen, 2007, Experiment 2) to retrieve the name of the visual objects (e.g., the beaver) before the spoken target word (e.g., 'beaker') starts to unfold, no increased overt attention to phonological competitors is observed.

Shifts in eye gaze based on *semantic* information appear to be due to semantic similarity rather than all-or-non categorical knowledge. Huettig and Altmann (2005) found that the probability of fixating a semantic competitor (e.g., a trumpet on hearing 'piano') has been found to correlate significantly with the semantic similarity between target (e.g., piano) and competitor (e.g., trumpet) as derived from semantic feature production norms (Cree & McRae, 2003). Similarly, Huettig, Quinlan, McDonald, and Altmann (2006) showed that semantic similarity between target and competitor as derived from corpus-based measures such as Latent Semantic Analysis (Landauer & Dumais, 1997) and Contextual Similarity (McDonald, 2000) predicted fixation behavior.

Shifts in eye gaze based on *visual* information (the type of mapping I focus on in the present chapter) could reflect a match between visual information accessed from hearing the spoken word (e.g., the prototypical shape of a snake on hearing 'snake') and the visual features accessed from viewing the objects in the display (the particular properties of a displayed cable) *or* the stored knowledge about the prototypical shapes of the concurrent visual objects (the stored knowledge about the typical shape of cables). In the first case the match of the language-derived information is with the *perceptual* properties of the visual input but in the second case the match is with the *stored* knowledge about the depicted objects. This question is difficult to address experimentally for shape-related items (e.g., shape-cable) because objects tend to retain their

shape. Color on the other hand allows experimental exploration of this issue because conceptual color attributes (the knowledge that frogs tend to be green in Northern Europe) can be dissociated from perceptual attributes (the perceptual properties, i.e. the greenness of the co-present frog) because surface color and prototypical color can be different (e.g., a yellow frog or the picture of a frog presented in black and white).

Huettig and Altmann (2011), to investigate this issue, presented participants with spoken sentences which included a critical target word whose concepts were associated with a prototypical color (e.g., “spinach”, spinach is typically green) while their eye gaze was monitored to displays of, (a) black and white line drawings of objects associated with a prototypical color (e.g., the black and white line drawing of a frog), (b) photographs of objects associated with a prototypical color (e.g., the color photograph of a yellow frog), and (c) objects *not* associated with a prototypical color (e.g., a blouse) but presented in the prototypical color of the target concept (i.e., a green blouse). Participants were asked to look at the screen and to listen carefully to the sentences (a 'look and listen' task, cf. Huettig & Altmann, 2005). 'Look and listen' tasks allow researchers to evaluate whether particular (e.g., competition) effects are a more general feature of language-vision interactions or whether they are limited to certain specific goal-directed task demands.

These studies revealed that adults' color-mediated shifts in eye gaze are mostly due to the surface colors of the objects in the visual surroundings rather than stored color knowledge accessed from viewing the objects. Effects of surface object color were large and immediate (at least when no competing representational matches were present between the spoken target word and the visual objects) but effects of stored object color knowledge were very small and occurred late.

Other studies have shown that the timing of shifts in eye gaze mediated by phonological, visual, and semantic levels of processing is co-determined by the type of information in the visual environment (see Huettig & McQueen, 2011), the timing of cascaded processing in the word- and object recognition systems, and the temporal unfolding of the speech signal (see Huettig & McQueen, 2007).

In sum, the study of language-vision mapping in mature language users has revealed that it is a complex behavior involving a tight coupling between visual and linguistic processing systems. There are however still many unknowns about how language affects visual orienting. One unanswered set of questions concerns the *development* of such language-vision interactions. Are children's linguistic representations structured in such a way that leads them to behave them in a similar manner as adults during online language processing? It is conceivable that rapid online activation of specific conceptual attributes (e.g., the prototypical color of objects) coupled with efficient online visual processing only emerges with accrued experience. On the other hand, it is possible that a tight language-vision mapping is foundational to human cognition and thus evident very early in development.

### **Background: Relevant developmental research**

One may ask how likely it is that young children's conceptual processing and language-vision mapping differ from adult-like behavior. Recent studies suggest that young children's semantic/conceptual knowledge is quite advanced. Styles and Plunkett (2009) for instance presented 18- and 24-month-olds with noun pairs in quick succession. The nouns were either related (e.g., "... cat dog") or unrelated (e.g., "... plate dog"). Target and distractor pictures (e.g., a dog and a ship) were presented 200 or 400 ms after target word onset. Styles and Plunkett (2009) found that 24-month-olds fixated targets (e.g., the dog) longer when the target was

preceded by a related word (e.g., “cat”). The authors argued that this priming effect reflects that “infants integrate each word they learn into a complex, adult-like semantic system which encodes relatedness between words” (p.20). Similarly, Torkildsen, Syversen, Simonsen, Moen, and Lindgren (2007) found that 24-month-olds displayed ERP N400 negativity for target words preceded by a semantically unrelated word compared to target words which were preceded by a semantically related word. The N400 event-related potential component reflects a response to a semantic anomaly in the preceding context (Kutas & Hillyard, 1980). Torkildsen et al. (2007) concluded that the N400 in their study reflects “processing of semantic relationships, although influence of associative relations cannot be excluded” (p.348). Other, earlier, studies, demonstrated that young children have some knowledge of prototypical examples familiar objects. Macario (1991) for instance found that they performed above chance in a forced choice test in which they were required to indicate the color of well-known foods (see also Meints, Plunkett, & Harris, 1999). Finally, young children have been found to recognize taxonomic relationships between words (Bauer & Mandler, 1989; Markman & Hutchinson, 1984).

For the present research on children's language-vision mapping past investigations of children's eye gaze behavior are particularly relevant. Developmental psychologists have been studying children's cognitive processing by means of eye gaze for over 20 years using the preferential looking paradigm (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987). In this method, children typically view two side-by-side screens while listening to some auditory input. Their eye gaze is recorded and later analyzed. Children's looking preferences are taken as an indicator of processing.

Using this task, Naigles and Gelman (1995) asked toddlers to find a referent that matched a given label (e.g., “dog”). When the specified referent was present (e.g., as one of two puppets)

toddlers consistently chose the matching screen over the mismatching one (see also Holich, Hirsh-Pasek, & Golinkoff, 2000). When the specified referent was not present toddlers' looking behavior was far less determinant. This suggests that toddlers also know when a referent is not present. Thus, on hearing a spoken word, toddlers appear to access conceptual information associated with that word and then search for the referent in the visual displays.

Many developmental studies have investigated comprehension and production of absent reference (e.g., Greenfield, 1982; Huttenlocher, 1974; Huttenlocher & Smiley, 1987; Veneziano & Sinclair, 1995). Saylor (2004) presented 12- and 16-month-olds with simple color panels (red, blue, yellow, green) matching the color and spatial location of a mentioned absent object (e.g., a blue car) or matching the color and spatial location of a non-mentioned absent object. The infants showed comprehension of absent reference by directing more looks and gestures to the display matching the absent object than the display matching the non-mentioned absent object.

Ganea, Shutts, Spelke, and DeLoache (2007) taught 19- and 22-month-olds the name for a toy. Later they removed the toy and told them that it had become wet (i.e. a change of state). The 22-month-olds (but not the 19-month-olds) could subsequently identify the toy on the basis of this information. Thus, 22-month-olds, given the right circumstances, are able to update mental representations of absent objects based on what other people tell them.

Note however that, except for the Naigles and Gelman (1995) and Saylor (2004) studies, missing referent studies investigating conceptual development have presented children with either fully-matching or fully-mismatching named target objects. Such studies therefore do not tell us whether young children represent *individual* properties of concepts/objects such as prototypical color in a manner that they are readily accessed and used during online language-mediated visual orienting.

Young children for instance may know that bananas are yellow and not blue but they may not be able to abstract the yellowness away from the concept of bananas rapidly when hearing “banana” (cf. Bornstein, 1985b). Or, early in development there may be an increased focus on certain object attributes (e.g., object shape). Shape for instance tends to be a more reliable diagnostic property of objects than color. Man-made objects tend to vary in their color but have a distinct shape. Most theories of object recognition (e.g., Biederman, 1987; Marr & Nishihara, 1978) therefore have emphasized the role of edge-based information rather than surface information. Indeed, many developmental studies have found that young children treat shape (e.g., Graham & Diesendruck, 2010) but not color as a defining attribute of new words (e.g., Graham & Poulin-Dubois, 1999; Landau, Smith, & Jones, 1988; see also Bornstein, 1985a).

### **Color-mediated language-vision mapping in young children**

In a series of eye-tracking studies (Johnson & Huettig, 2011; Johnson, McQueen, & Huettig, 2011; Mani, Johnson, McQueen, & Huettig, in press) we have recently begun to investigate the development of language-mediated visual orienting systematically. Johnson and Huettig (2011) used sixteen words typically known by Dutch 36-month-olds as search targets. Twelve of these words referred to objects associated with a prototypical color (*aardbei* ‘strawberry’, *sinaasappel* ‘orange’, *kikker* ‘frog’, *wortel* ‘carrot’, *banaan* ‘banana’, *brandweerauto* ‘fire truck’, *peer* ‘pear’, *olifant* ‘elephant’, *varken* ‘pig’, *tomaat* ‘tomato’, *komkommer* ‘cucumber’, *zon* ‘sun’). The remaining four words referred to objects which are *not* associated with a prototypical color were not (*lamp* ‘lamp’, *huis* ‘house’, *tafel* ‘table’, *bed* ‘bed’).

Forty-two Dutch-learning 36-month-olds were presented with 3 types of trials. During Target Present Trials, participants were presented with two familiar objects (e.g., a sock and a fire truck) on a screen and asked to find one of the objects (e.g., “Can you find the fire truck?”).

During Color-matched Distractor Trials and Unrelated Distractor Trials, participants were presented with two objects that were identical except for color (e.g., the same ball colored once in red and the other time in green) and asked to find an object that was not present (e.g., a frog). Critically, during Color-matched Distractor Trials there was a match in color between the prototypical color of the concept referred to be the spoken target word (e.g., frog) and one of the colored objects in the display (e.g., the green ball but not the red ball). The prediction was that the 36-month-olds would look longer at the color-matched distractors than the color-mismatched distractors if they have stored prototypical color knowledge and use it during online language-vision mapping (e.g., when hearing "frog" they should look longer at the green ball than the red ball). The Unrelated Distractor Trials served as a control condition. In these trials children also saw two objects that were identical except for color (e.g., the same chair colored once in red and the other time in gray) but there was no match in color between the spoken target word (e.g., lamp) and either of the colored objects in the display (e.g., the red chair and the gray chair).

Children sat on a caregiver's lap in a dimly lit room about 1m from a large television screen on which the test trials were presented. The caregivers were listening to masking music over headphones. After the experiment a flip book was used by the experimenter to test the children's color knowledge. The children were asked to point to one of four differently colored objects (e.g., "Where is the red one"). The colors tested were red, blue, green, yellow, orange, pink, and gray. Children pointed to the correct object on 74 % of these color test trials. Thus, the 36-month-olds' color label knowledge was well above chance.

Johnson and Huettig (2011) found that during the experimental trials, targets (e.g., the fire truck) were fixated significantly more than the control objects (the sock) from 300 ms after the onset of the spoken target word (e.g., "fire truck"). Importantly, color-matched distractors

(e.g., the green ball) were also fixated significantly more than the control objects (the red ball). This effect however was slightly delayed reaching significance during 1,300 to 1800 ms after the onset of the spoken target word (e.g., "frog"). There was no corresponding bias in fixations to the target in the Unrelated Distractor trials. Thus, the children readily retrieved prototypical color knowledge on hearing the spoken target words (e.g., "frog") and fixated more upon an object that had the same (e.g., a green ball) than a different (e.g., a red ball) surface color.

The proportion of time spent looking away from the screen supports this conclusion. Initially on hearing the critical target word (1,000 to 2,500 ms after target onset) the 36-month-olds looked less often away from the screen during both Target Present Trials and Color-matched Distractor Trials than Unrelated Distractor trials suggesting that for both target and color-matched distractor something interesting captured children's attention. During the 2,500 to 4,000 ms time window however the pattern reversed. During this late time region children's fixation in Color-matched Distractor Trials patterned more like their fixations in Unrelated Distractor trials. In other words, the color-related distractors could not hold the 36-month-olds' attention as much as the targets could.

The difference between these findings and past missing referent studies is that the Johnson and Huettig (2011) study demonstrates that 36-month-olds are sensitive to the overlap in *specific* conceptual features retrieved on hearing spoken words and *specific* features of objects in the concurrent visual environment. 36-month-olds rapidly extract the greenness from their stored knowledge of frogs, recognize this same trait in other (concurrent) objects, and use this knowledge online to direct eye gaze. This demonstrates that there is a strong link between overt eye gaze and lexical processing in 3-year-olds. It is also noteworthy that this effect occurred for conceptual features which are not the most predictable indicator of object identity, namely color

(cf. Davidoff and Mitchell, 1993).

The question that arises therefore is whether the color effect in Johnson and Huettig (2011) was mediated by stored verbal color labels or more visual knowledge. When listeners hear the word "frog", do they access an associated stored color label (GREEN), which makes them more likely to look at green things in their visual surroundings? Or, alternatively, do listeners on hearing "frog" access a target template, a sort of veridical description of the target (see Huettig, Olivers, et al., 2011, for further discussion) which then leads to a match with items matching this 'perceptual' template? Davidoff and Mitchell (1993) for instance have argued that "3-year-olds have more difficulty matching object colors with mental templates than they do with color naming" (p. 133) based on the finding that their 3-year-old participants tended to successfully judge that a banana is colored yellow in a verbal task but failed to choose the yellow banana as the correct one from differently colored bananas.

To examine this issue, Johnson et al. (2011) tested 48 Dutch learning toddlers (average age: 751 days) who lacked reliable color term knowledge. Sixteen Dutch words commonly known to 2-year-olds were selected as spoken target words. Six of those referred to foods with a prototypical color (e.g., strawberry), another six referred to animals with a prototypical color (e.g., frog), and four referred to objects not associated with a prototypical color (e.g., table). During the Target Trials the 2-year-olds were asked to find one of the two objects presented on a screen (e.g., Can you find the banana?, a bike and a banana were displayed). During Related Distractor Trials they were asked to look for an absent object (e.g., a frog) while being presented with two objects with one of them sharing either a color (a green truck and a yellow plane) or a semantic relationship with the target word (a bird and a red plane). During Unrelated Distractor Trials toddlers were asked to look for an absent object (e.g., a house) while being presented with

two completely unrelated objects (e.g., a sandwich and a toothbrush). Note that the items were counterbalanced across toddlers (i.e. no toddler saw the same image twice) and that images shown during Related Distractor Trials were identical to the images shown during Unrelated Distractor Trials (i.e. only the spoken target words differed). This design allowed assessment of how toddlers' fixation during Related Distractor Trials and Unrelated Distractor Trials were influenced by the (color or semantic) relationships between target word and concurrent pictures.

During Color Label Trials, presented at the end of the experiment, toddlers were asked to look at one of two smiley faces ("Look at the blue one"), which were identical except for their color. These trials testing for color label knowledge were unlike most previous studies of color label knowledge because they did not require toddlers to produce a motor response (e.g., pointing, Davidoff and Mitchell, 1993; Gleason, Fiske, & Chan, 2004) or a verbal response (e.g., Johnson, 1977).

Johnson et al. (2011) found that on hearing the spoken target words, toddlers looked immediately at the targets (e.g., on hearing "banana" they shifted their eye gaze immediately towards the banana). Importantly, during the time region from 1 second to 2 seconds after word onset they also looked significantly more at the objects that were either color or semantically related to the named absent target (e.g., on hearing "frog" they were more likely to look at a green truck and a bird than completely unrelated objects). Thus, 2-year-olds recognize partial perceptual-conceptual matches between heard words and seen objects, i.e. they naturally map mental representations accessed on hearing words and mental representations accessed from viewing visual objects. Importantly, Johnson et al. (2011) tested 2-year-olds who lacked reliable color term knowledge to examine whether language-vision mapping is mediated by stored verbal labels (i.e. the lexicalized label GREEN). Such a possibility is supported by responses of adult

participants in free word association tasks. Participants in such tasks typically produce the answer "green" when asked to write down the first word that comes to mind when reading the word *frog* (Nelson, McEvoy, & Schreiber, 1998). In other words, Johnson et al. (2011) tested whether language-vision mapping can be driven via a direct route (e.g., via accessing some sort of 'perceptual template') or whether such mapping is more indirect (e.g., that mediation by color label knowledge is necessary and thus proficient mapping develops late, cf. Bornstein, 1985b).

The findings of Johnson et al. (2011) strongly suggest that language-mediated shifts in visual orienting are independent of knowing color labels, i.e. such shifts are not mediated by stored lexicalized color labels. How sure can we be that the toddlers in Johnson et al. did not use any color label knowledge for their visual orienting? Caregivers of the toddlers were asked to indicate whether their child knew any of color labels and how accurately those color labels were used. These parental report data suggest that only 12 of the 48 toddlers knew more than one color term correctly at least 'most of the time'. 'Most of the time' of course does not indicate that the child has necessarily full and reliable comprehension of color labels. Moreover, parental report may overestimate or underestimate toddler knowledge (e.g., Tomasello & Mervis, 1994). For instance a child may say that blue is their favorite color but pick up a ball of a different color when asked to pick up a blue ball. Or, a child may memorize a phrase such as "blue ball" without understanding what blue means. Preferential-looking data in contrast appears to be more reliable (e.g., Houston-Price, Mather, & Sakkalou, 2007). Johnson et al. excluded all trials from the dataset for which caregivers had reported that the children knew some color labels and observed the same overall pattern of results. In any case, the primary data in the Johnson et al. (2011) study comes from the preferential-looking task and thus the most appropriate test of whether toddlers' color label knowledge influenced performance in the experiment should also be based

on preferential looking. The analysis of the Color Label Trials (e.g., "look at the blue one" with a red and blue smiley presented) revealed that the toddlers comprehended appropriately at most two colors. The experimental results showed the same overall pattern when all trials involving these two colors was taken out. Thus, there was a clear within toddler dissociation in the preferential looking task which gets around the issue of precisely which few color labels some of the toddlers may have known and how well they did so. Words such as "strawberry" resulted in shifts in eye gaze to red things but color words such as "red" did not. Two-year-olds look to color-matched competitors even if they do not know the label for that color. The Johnson et al. (2011) results do not rule out that adults have both direct and indirect routes linking color knowledge of words such as 'strawberry' to color concepts such as red. What the Johnson et al. (2011) results show however is that the direct routes exists before the indirect route (i.e. mediation via lexicalized color labels) has a chance to develop.

Finally, Mani, Johnson, McQueen, and Huettig (in press) have recently investigated whether these results can be replicated using a referent-present experimental design. The Johnson and Huettig (2011) and Johnson et al. (2011) studies strongly suggest that toddlers rapidly extract color attributes on hearing spoken words referring to objects with a typical color, recognize this same trait in other (visually concurrent) objects, and use this knowledge online to direct eye gaze. In both studies however the children were asked to find objects not present on the screens, i.e. the studies used referent-absent tasks. The understanding of absent reference is a crucial ability during the development of language processing (cf. Saylor, 2004) as often spoken language is about things that are not physically present. It is however conceivable that asking children to find objects not present on the screen leads them to search for additional information which might help them to integrate information arriving through visual and speech channels. In

other words, referent-absent tasks may encourage toddlers to extract information which is not routinely retrieved during language-vision mapping.

Mani et al. (in press) used a primed inter-modal preferential looking task (see Arias-Trejo & Plunkett, 2009; Styles & Plunkett, 2011; for similar tasks investigating semantic priming). Toddlers were presented with a prime label followed by the label for one of the images presented on screen, e.g., children heard “I saw a strawberry...cup” while looking at a red cup and a blue chair. The same stimuli as in Johnson et al. (2011) were used. Thus, the only difference to the Johnson et al. (2011) study is that after being presented with the prime label (e.g., “strawberry”), toddlers also heard the label for the target on the screen (e.g., “cup”). If the effects of color in the previous studies were driven by children struggling to find a match between the spoken instruction (e.g., “strawberry”) and the mismatching objects (e.g., the red cup) presented to them, there should be a reduced preference for color matching objects in the current experimental task. If on the other hand toddlers readily activate stored color knowledge during spoken word processing, they should show a robust preference for the target in color matching trials but not in unrelated trials. Mani et al. found that despite being presented with the spoken target (e.g., “cup”), i.e. facilitating an easy match between auditory and visual stimuli, toddlers show a robust preference for the color matching object (the red cup) when primed by a color-matching label (e.g., “strawberry”). The results of the Mani et al. (in press) study thus provide strong evidence for the retrieval of color knowledge in both referent-present and referent-absent designs and for its rapid use during language-vision mapping in toddlers.

## **Conclusion**

In this chapter I have discussed the results of three preferential looking experiments which investigated young children's use of color during the mapping between language-derived

and vision-derived representations. The findings are clear: Toddlers readily retrieve stored knowledge about typical color and use this knowledge online to direct eye gaze to objects in the visual environment which match on the same trait. They do so even if they have plenty of time to recognize the objects for what they are (e.g., red planes and not strawberries). Even 24-month-olds who lacked color label knowledge exhibited the same behavior. This demonstrates that language-mediated shifts in visual attention are not necessarily mediated by stored lexicalized (color) labels. Though adults may have both direct and indirect routes linking color attributes of words such as “frog” to color concepts such as green, the results demonstrate that the direct route exists before the indirect route has had a chance to develop. The findings thus cast doubt on the claims in the literature that (older) children tend to rely on verbal encoding to remember how familiar objects are typically colored (e.g., Davidoff & Mitchell, 1993; Gleason et al., 2004). Moreover, claims that "a proper map connecting names and perception is late in developing" (Bornstein, 1985b, p.78), appear to be unfounded. In other words, young children are not 'Farbendumm' (Nagel, 1906) but rather 'Farbenclever'.

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