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Perceptual Representation of Color in Abstract Non-Color Word Processing

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Perceptual Representation of Color in Abstract Non-Color Word Processing

Abstract

Three experiments showed that naming latencies were significantly shorter when the patch color was consistent with the object's typical color relative to when they were inconsistent. Such color simulation was also found for verbs involving an object with color and words psychologically-related to color, indicating that color simulation is not limited to situations where there is a concrete, direct connection between the concept and the color information. Results from SOA manipulation indicates a more rapid activation of color information for the words psychologically-related to color, followed by activation of color for object nouns, and slowest color activation for verbs, providing the first clear demonstration that the nature of the concept-color connection affects the time course of color simulation.

Introduction

Comprehending sentences or verbs depicting actions has been demonstrated to activate the motor and pre-motor cortex in many studies using both behavioral and neuro-imaging measures. For example, studies using Positron Emission Tomography (PET) to reveal the brain mechanisms involved in processing verbs related to a particularly conceptual category have found reliable activation in the left pre-motor cortex when right-handed subjects retrieved information about tools or named pictures of tools (Grabowski et al., 1998; Martin et al., 1996). Further studies using other functional imaging methods show similar results. For instance, a functional magnetic resonance imaging (fMRI) experiment conducted by Tettamanti et al. (2005) showed that visuo-motor circuits responsible for action execution and observation were activated when participants were listening to action-related sentences. These data provide the first direct evidence for the notion that the observation–execution matching system (i.e., the mirror-neuron system) may play an essential role in the understanding of actions even the actions are performed by others as depicted in the sentences.

Similarly, Hauk et al. (2004) applied event-related fMRI to demonstrate that a task involving passive reading of action words about face, arm, or leg (e.g., to lick, pick, or kick) differentially activated motor areas that are activated by actual movement of the tongue, the fingers, or the feet. Interestingly, such somatotopic activation seems to be highly automatic as they were found even when

subjects were presented with action words, while simultaneously performing a secondary task (Pulvermüller, Shtyrov, & Ilmoniemi, 2005). In addition, judging whether a verb is a real word or a pseudo-word has been demonstrated to elicit stronger high-frequency EEG activity at the electrodes positioned above primary motor cortex for action words (Pulvermüller, Lutzenberger, & Preissl, 1999).

Most recently, Kemmere et al. (2008) demonstrated that there were brain regions activated when participants made semantic judgments about verbs and more interestingly the regions activated were different depending on the semantic contents of the verbs. They used several classes of verbs in their study, namely, running verbs (e.g., run), speaking verbs (e.g., shout), hitting verbs (e.g., hit), cutting verbs (e.g., cut), and change of state verbs (e.g., shatter), which vary in the level of their involvement of five distinct semantic components, e.g., action, motion, contact, change of state, and tool use. For example, running verbs involve only two components which are action and motion, and cutting verbs involve all five components. Their results showed that the action component elicited activation in the primary motor and pre-motor cortices, the motion component in the posterior-lateral temporal cortex, the contact component in the intra-parietal sulcus and inferior parietal lobule, the change of state component in the ventral temporal cortex, and the tool use component in a distributed network of temporal, parietal, and frontal regions.

Buccino et al. (2005) found that listening to sentences containing information about hand-

related actions moderated motor evoked potentials of the hand muscles, but listening to sentences containing information about foot-related actions moderated motor evoked potentials of the foot muscles.

Using action-sentence compatibility effect, Glenberg and Kaschak (2002) found that sentences describing a movement in a certain direction could interfere with responses executed in a different direction. They required subjects to determine the sensibility of sentences by making a response, namely, moving towards or away from their bodies. The results showed that it took longer for participants to judge the sensibility of sentences when the directions implied in these sentences were opposite to the response. For example, if the direction of the response was moving towards our body, then the sentence "Close the drawer" whose meaning is to move away from the body would delay the response.

Similarly, it was shown that hand responses to sentences describing manual rotation were faster when both the manual response and the sentence shared the same direction of rotation than when they differed in rotation direction (Zwaan & Taylor, 2006). Accordingly, it has been suggested that sentences involving rotations activate a motor program for manual rotation in the listener.

Finally, Glover (2004) first primed participants with names of objects (e.g., apple or grape) who then had to reach and grasp a following target. The target size (wide or narrow) was either consistent or inconsistent with that of the object. Early in the reaching movement the

prime had an impact on the aperture size between thumb and forefinger of the action grasp, but this aperture size would change to match the target's size during later stages, which suggest that the comprehension of an object word involves automatic simulation of components afforded by the related motor action.

What the above studies have in common is that they suggest that representations of action information associated with a verb, phrase, sentence is part of their conceptual meaning and can be simulated or automatically triggered when they are processed in a linguistic context.

There are less but growing number of studies on perceptual simulation, i.e., the activation of other sensory properties like object shape, orientation and resolution in language processing, which complements evidence about motor simulation to more fully support claims of embodied cognition. One of the first evidence for perceptual simulation was from Zwaan, Stanfield, and Yaxley (2002) who asked their participants to read and comprehend a sentence for later recognition. A picture depicting an object would then be shown and participants named the picture. The sentence could be consistent or inconsistent with the picture, depending on whether the object described in the sentence implied a visual shape same as or different from the shape of the object depicted in the picture. For example, if the sentence was, 'The ranger saw the eagle in the sky'), it would be consistent with picture depicting a flying eagle but inconsistent with a picture depicting a sitting eagle. This pattern was exactly the opposite for the sentence, 'The

ranger saw the eagle in its nest'. Naming latency was found to be significantly shorter for the consistent sentence-picture pairs than for the inconsistent pairs, suggesting that the shape information of the object referred by the word in the sentence (i.e., the eagle) was activated and interacted with the shape information perceptually given in the picture.

Diane, Kiki, and Rene (2007) in the study phase asked their participants to do a property verification tasks deciding whether a concept name (e.g., apple) matched with a property that was either visual (e.g., shiny) or non-visual (e.g., tart). They later in the test phase presented pictures of objects and asked participants to recognize which of these objects were studied earlier. The results showed better recognition memory of the object in both response time and accuracy measures if the concept name for the object had been presented with a visual property than with a non-visual property.

These results indicated that the perceptual (i.e., visual) properties of a concept were more closely tied or may be part of the meaning representation of the concept itself, relative to non-perceptual (i.e., non-visual) properties. That is, when judging about the visual properties of the concept, the concept itself is activated more and hence recognized better later, relative to the non-visual properties.

Concept representation is not totally abstract and modality-free as it consists in part of the explicit representation of modality-specific information (e.g., visual properties) and concept understanding leads to simulation of such modality-specific information. This supports

the perceptual symbols theory (Barsalou, 1999) that sensorimotor simulations underlie the representation of concepts. While the studies on perceptual simulations have been concerned with shape, direction, size, the work demonstrating mental simulation of color information was scant, even though color is a very salient feature in vision and color information is also prevalent.

Klein (1964) used words denoting color-diagnostic objects in Stroop paradigm, requiring subjects to name the ink color of each word. The object noun could be in its typical or an incongruent color. A standard Stroop effect was found- color naming was faster in typical color condition. Following Klein's work, Naor-Raz, Tarr, and Kersten (2003) also demonstrated such Stroop effect by further arguing the semantic representation of color in object nouns.

Apparently, Klein (1964) and Naor-Raz, Tarr, and Kersten (2003) have shed light on the conceptual representation of color in concrete words such as object nouns. In addition, in studies of motor simulation, other than action-related sentences, isolated action verbs have been presented and found to induce motor simulation. The above studies taken together raise the possibility that color simulation may also be demonstrated in linguistic units of words, even those less concrete than object nouns such as verbs and words psychologically related to color.

Thus, in addition to object nouns which serve as the baseline, the current study also included two more types of words, verbs and words

psychologically associated with colors. Verbs are concepts that have no direct concrete reference to perceptual color information. However, verbs, in denoting actions, are associated with agents and objects. For example, the verb 'plant' implies an action involving hands and trees. As mentioned in the introduction, there have been studies showing that body parts as agent information were simulated in processing action verbs, that is, reading 'lick' activates face area and reading 'kick' activates foot areas in motor cortex. It is possible that objects denoting by verbs may also be mentally simulated. To examine this in the general context of the focus of color information, the current study examined whether color information associated the object of a verb is simulated when reading a verb.

In addition, it was argued that the brain could simulate not only the perceptual and motor but also the mental states during the interaction with the world's referents (e.g., Barsalou, 1999, 2008; Damasio, 1989; Glenberg, 1997; Martin, 2001, 2007; Thompson-Schill, 2003). For example, the simulation of the word 'cat' involves how a cat looks, sounds and feels, and how one feels emotionally around them. The current study also took these emotional reenactments into consideration. Based on one's life experience, color can be associated frequently and indicate some emotional state. For example, black indicates fear, white indicates sadness, and red indicates danger and happiness. Therefore, abstract words such as fear, festival, and danger are indirectly connected with and imply a specific color. When reading such words, will there be activation for their implied color?

Putting verbs and words psychologically related to color together, they are both abstract concepts in the sense that they do not refer to concrete objects and would imply color as objects do but are just indirectly associated with the perceptual color information. Words psychologically related to color share the same psychological functioning with physical color. For example, red color could exert the feeling of danger (e.g., Elliot et al., 2007; Goldstein, Davidoff, & Roberson, 2009; Hill & Barton, 2005; Mehta & Zhu, 2009). Thus, reversely should color representation be demonstrated for words psychologically associated with color, it would be an interesting and significant extension to our understating of the scope of applicability for the claims of mental situation. Further, it would also be informative to compare their effect size, to see among the three types of words, which will show stronger effect of color simulation, the object nouns with direct connection to color, or the verbs or words indirectly or psychologically associated with color?

Experiment 1

Method

Participants A group of twenty-six participants (12 males, mean age \pm SD = 23.0 \pm 1.5) were recruited from South China Normal University, Guangzhou, China. All were native Chinese speakers and all signed informed consent form. All had normal color vision as assessed by the City University Color Vision Test (Fletcher, 1980). **Materials and design** The stimulus set included 30 test words and 30 filler words. The test items consisted of 10 verbs (e.g., '生长'-grow), 10 words psychologically-related to

color (e.g., ‘邪恶’ - evil), and 10 concrete nouns (e.g., ‘芒果’ - mango). For simplicity, the psychologically-related were short-handed as psych-color words. The ten nouns were taken from the phrases used in the Experiment 1 of Lu et al.’s study and all referred to objects. These three types of words were matched in stroke number and visual word frequency (Modern Chinese Frequent Words Dictionary, 1990). All of the test items were selected to imply color and none of the 30 filler words imply color (e.g., ‘步伐’- step). Each word was designated with a color which is supposedly implied by and hence congruent with the word. This was confirmed in a rating study involving 20 participants not in any of the formal experiments.

Participants were given each of the test words and asked to write out a color that they considered most related to that word and rated how strong the color-word association was. Results showed that for each of the test words in the stimulus set, more than 75% participants wrote out the color designated. The color-word association strength rating for every test word and its congruent color was higher than 5 in a 7-point Likert scale. There was no significant differences across the three word groups neither association consistency, nor association strength ($F_s < 1$), ensuring good materials match across prime word type.

Each test word was paired with two different colors: its congruent color and an incongruent color. For example, ‘苹果’ (apple) would be followed by either a red color patch to make a congruent pair or a white color patch to make an incongruent pair. Thus, the design was a 3

(Prime type: verb, psych-color word, object noun) \times 2 (Congruency: congruent, incongruent) design with Prime type and Congruency as two within-subject factors.

Each of the 60 word items was paired with two color patches, producing 120 trials in total. These 120 trials were evenly divided into two blocks, each of 60 trials. All 30 test words appeared in each block and appeared only once. Half of them were paired with congruent color in one block and the incongruent color in the other block. For the other half, it was the opposite. Hence there was equal number of congruent and incongruent trials within each block.

To ensure participants read the word carefully, an italic probe word would be presented at the end in half of the filler trials. Participants were instructed to judge whether the italic words was the same as the previous one by pressing one key for yes and another for no. Half of the times, the probe word would be different from the filler word but the other half, it would be the same. That is, participants would need to make a yes response for half of these catch trials and a no response for the other half.

Procedure Stimulus presentation and response acquisition were controlled by the E-Prime software running on an IBM-compatible computer. Response latencies were recorded by computer using a voice-activated key, and accuracy was recorded and scored by the experimenter.

All participants were tested individually in a dimly lit room. Instructions were displayed visually onscreen and explained by the

experimenter. Participants completed 10 practice trials before the actual testing. Each trial began with a central fixation cross for 500 ms, followed by a 400-ms presentation of a word. At the offset of the word, a color patch appeared onscreen. Participants should name the color patch as quickly as possible, while maintaining high accuracy. If participant failed to respond within a 5000 ms time window, the program would regard it as an error. The color patch was turned off after response or at the end of the response window. In some catch trials, there would also be a two-character test word presented after the patch and participants should indicate whether this word was the same as the prime word or not. They pressed one key 's' for yes response and another 'n' for no response. No feedback on the response accuracy or speed was given to the participants.

The items were pseudo-randomized across participants with no two successive trials requiring the same naming response. The experimental session was made up of two blocks with a 1-minute break between blocks. At the beginning of each block, there were three warm-up trials whose data were removed from the data analyses. Results and Discussion The mean naming times across all participants for the different conditions are illustrated in Table

1 for Experiment 1. ANOVA showed a significant main effect for Prime type ($F(1, 25) = 29.92, MSE = 76741, p < .001$; $F(2, 18) = 8.33, MSE = 28900, p < .005$) and for Congruency ($F(1, 25) = 10.83, MSE = 29714, p < .005$; $F(1, 9) = 3.88, MSE = 14997, p = .08$), although for Congruency the item analysis significance was marginal. The psych-color words elicited faster patch color naming than verbs ($F(1, 25) = 50.05, MSE = 109121, p < .001$; $F(1, 9) = 9.56, MSE = 42851, p < .05$) and object nouns ($F(1, 25) = 31.74, MSE = 120805, p < .001$; $F(1, 9) = 17.27, MSE = 43842, p < .005$), but the verbs and object nouns did not differ from each other ($F(1, 25) = .17, MSE = 297, p > .1$; $F(1, 9) < .005, MSE = 6, p > .1$). The interaction between Prime type and Congruency was only significant by participant ($F(2, 50) = 4.72, MSE = 8799, p < .05$), but not by item ($p > .1$).

As expected, response time for incongruent color was significantly longer than congruent color ($F(1, 25) = 10.83, MSE = 19809, p < .005$; $F(1, 9) = 3.88, MSE = 9998, p = .08$). Planned comparisons showed that, however, the congruence effect was present only for the psych-color words ($F(1, 25) = 15.7, MSE = 82790, p = .001$; $F(1, 9) = 11.04, MSE = 20658, p < .01$) but not the verbs and object nouns ($F_s > .1$).

Table-1: Mean Response Times (in Milliseconds) per Word type as a Function of Color Version

Word type \ Color version	Verbs		Psych-color words		Object nouns	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Congruent color	762	91	672	81	758	92
Incongruent color	768	97	728	89	779	114

Not relevant to our main interest, the absolute performance differences across the three types of prime words may reflect some special attributes of the words psychologically associated with color. For example, such words as fear, danger may enhance emotional arousal speeding up response non-specifically (hence, independent of whether the following patch was congruent or incongruent in color), relative to verbs and nouns that lack emotional content.

Critically, Experiment 1 showed that when a word was briefly presented for 400 ms, the color it implied was named faster than an irrelevant color. The results showed color simulation, or a clear effect of color activation in language comprehension for linguistic units such as abstract words.

It is surprising that such effects were only obtained for words psychologically associated with color, but not for verbs and object nouns. For example, given the direct connection between an object noun and the object's color, the noun words were expected to produce the clearest evidence of color simulation. However, this was not the case in our results where the congruence effect for nouns was 21 ms, though in the right direction (faster congruent than incongruent conditions) but non-significant. Noted that in Lu et al.'s study, effects of the typical color of an object were significant and increased with longer SOA and the 400 ms SOA in the present study was shorter than the shortest 600 ms in Lu et al.'s study, the current study increased SOA to 800, and 1000 ms in the next two experiments to see whether this effect

would become significant when more processing time on the prime was available. Results from Experiment 1 would be further discussed together with that from Experiment 2 and 3.

Experiment 2 and 3

Method

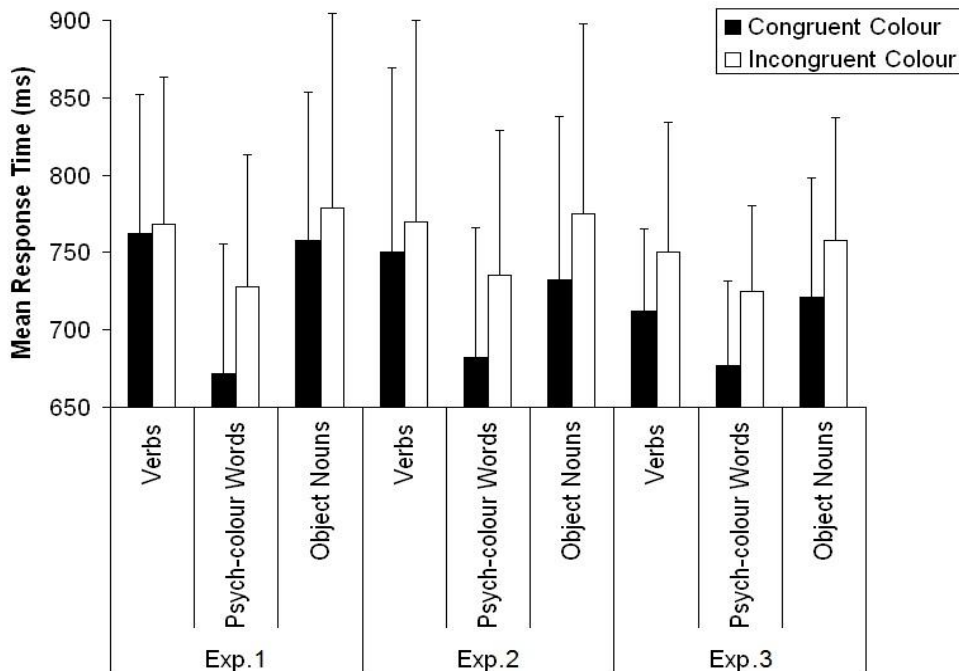
Participants and procedure Experiment 2 and 3 were identical to Experiment 1 except the SOA between the word prime and the target color patch was manipulated to further characterize the time course of the color simulation observed in Experiment 1. While the SOA was 400 ms in Experiment 1, it was increased to 600 ms in Experiment 2, and 800 ms in Experiment 3.

All aspects were as in Experiment 1 except where this SOA was relevant. Participants were taken from the same subject populations and formed the same inclusion criteria as in Experiment 1. Two groups of new participants were recruited for Experiment 2 (N=27, 13 males, mean age \pm SD = 23.1 \pm 1.2) and Experiment 3 (N=24, 12 males, mean age \pm SD = 22.1 \pm 1.0).

Results and discussion The mean naming times across all participants for different conditions are illustrated in Table 2 and 3 for Experiment 2 and 3, respectively.

The three-way interaction of SOA \times Word Type \times Congruency was obtained neither by participant ($p > .1$), nor by item ($p > .1$). See Fig. 1.

Figure-1: Mean response times for the three types of words followed by congruent color and incongruent color from Experiment 1-3.



For Experiment 2, ANOVA revealed significant main effects of Prime type ($F(1, 52) = 14.51$, $MSE = 42395$, $p < .001$; $F(2, 18) = 8.96$, $MSE = 16258$, $p < .005$) and Congruency ($F(1, 26) = 33.38$, $MSE = 60812$, $p < .001$; $F(1, 9) = 13.77$, $MSE = 21185$, $p = .005$). Specifically, response time was faster for color patches following the psych-color words, compared to verbs ($F(1, 26) = 18.06$, $MSE = 71815$, $p < .001$; $F(1, 9) = 10.05$, $MSE = 28034$, $p < .05$) and nouns ($F(1, 26) = 18.24$, $MSE = 54119$, $p < .001$; $F(1, 9) = 11.01$, $MSE = 20077$, $p < .1$) but was not significantly different between verbs and nouns ($F(1, 26) = .69$, $MSE = 1249$, $p > .05$; $F(1, 9) = .8$, $MSE = 662$, $p > .1$). As expected, color naming was faster for the congruent word-color pairs than for the incongruent pairs ($F(1, 26) = 33.39$, MSE

$= 40541$, $p < .001$; $F(1, 9) = 13.77$, $MSE = 14123$, $p = .005$). The interaction between Word type and Congruence was non-significant ($F < 1$). Planned comparisons showed congruence effects for both the psych-color words ($F(1, 26) = 33.39$, $MSE = 40541$, $p < .001$; $F(1, 9) = 17.59$, $MSE = 13910$, $p < .005$) and nouns ($F(1, 26) = 33.39$, $MSE = 40541$, $p < .001$; $F(1, 9) = 13.13$, $MSE = 9462$, $p < .01$), but still not for verbs ($F(1, 26) = 2.0$, $MSE = 11168$, $p > .1$; $F(1, 9) = 1.38$, $MSE = 1360$, $p > .1$).

For Experiment 3, the main effects of Prime type were significant ($F(2, 46) = 3.96$, $MSE = 19583$, $p < .05$; $F(2, 18) = 4.23$, $MSE = 10792$, $p < .05$) and Congruency ($F(1, 23) = 25.4$, $MSE = 58084$, $p < .001$; $F(1, 9) = 31.64$, $MSE = 22216$, $p < .001$). Specifically, color

naming was significantly faster when following the psych-color words than verbs ($F(1, 23) = 7.47, MSE = 21528, p < .05; F(1, 9) = 7.93, MSE = 11041, p < .05$) and nouns ($F(1, 23) = 9.65, MSE = 35486, p = .005; F(1, 9) = 9.91, MSE = 20439, p < .05$), but no significantly different between verbs and nouns ($F(1, 23) = .21, MSE = 1735, p > .1; F(1, 9) = .33, MSE = 1435, p > .1$). The interaction between Word type and Congruence was not significant ($F < 1$). As expected, color naming was faster for the congruent word-color pairs than for the

incongruent pairs ($F(1, 26) = 33.39, MSE = 40541, p < .001; F(1, 9) = 25.4, MSE = 38722, p < .001$). Planned comparisons showed a congruence effect for all three types of words: psych-color words ($F(1, 23) = 12.54, MSE = 26609, p < .005; F(1, 9) = 11.04, MSE = 21518, p < .01$), nouns ($F(1, 23) = 6.67, MSE = 31390, p < .05; F(1, 9) = 8.92, MSE = 17917, p < .05$), and verbs ($F(1, 23) = 8.56, MSE = 33297, p < .01; F(1, 9) = 9.61, MSE = 7149, p < .05$).

Table-2: Mean Response Times (in Milliseconds) per Word type as a Function of Color Version

Word type \ Color version	Verbs		Psych-color words		Object nouns	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Congruent color	750	110	682	83	732	103
Incongruent color	770	119	735	94	775	115

Table-3: Mean Response Times (in Milliseconds) per Word type as a Function of Color Version

Word type \ Color version	Verbs		Psych-color words		Object nouns	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Congruent color	712	55	677	55	721	80
Incongruent color	750	83	725	56	758	75

The pattern of results in Experiment 2 and 3 were the same as that in Experiment 1 in that all revealed a main effect of Prime type but no Prime type by Congruency interaction. As in Experiment 1, this absolute performance difference across the three types of prime words was interpreted to reflect enhanced emotional arousal for the words psychologically associated with color producing non-specific speed-up response independent of the congruency manipulation, relative to verbs and nouns. Regarding Congruence, both experiments showed a similar main effect as in Experiment 1, but the planned comparisons reveal some different results in that color

simulation was observed for verbs in Experiment 3 and for object nouns in both Experiment 2 and 3.

Discussion

The current study shows that color simulation can be demonstrated in less concrete words and indicates that effects of color simulation occurs at several different levels of language processing from sentences to the present level of individual nouns representing concrete objects, as long as the concept expressed implied color information. This result also suggests that the activation observed for the

typical color associated with the noun in Lu et al.'s study was not a contingent on the fact that the noun was embedded in a larger linguistic units carrying color.

Further, color simulation was also found for two other kinds of abstract words, including verbs and words with a psychologically-related color. This finding indicates that color simulation is not limited to situations where there is a concrete, direct connection between the concept and the color information but can be extended to situations where the concept is indirectly linked to color via another mental representation or when the two are psychologically associated based on some common physiological state.

Results from manipulating the SOA between the onset of the concept presentation and the onset of the patch probing the color activation indicate that at short SOA, words psychologically related to color lead to color activation as short as 400 ms and stayed around the same level of activation when SOA increased to 600 ms, and 800 ms (Exp. 1-3: 56: 53: 48 ms). For object nouns, the color activation was present but not significant until after 600 ms (Exp. 1-3: 21, 43, 37 ms). The verbs were the latest in activation, showing a trend of gradually increasing in effect size as SOA was increased but only achieved significance at the final SOA of 800 ms (Exp. 1-3: 6:20:38 ms). At the end, the level of activation was comparable for the nouns and verbs (noun: verb – 37:38 ms). These results do not seem to be confounded by the strength of association between words and colors which has been matched as shown in the pilot rating

study. Nor do they seem to be confounded by stimulus differences across word types, such as stroke number and word frequency, two of the most important factors indexing word visual complexity and difficulty in lexical processing.

It therefore seems that the extent to which color information is activated may not be solely dependent on the color-word association as subjectively rated but also on some other factors. One possible factor, for example, may be the number of alternative colors that can be associated with a word. Words psychologically associated to color typically only have one single color association but objects can quite often have more than its typical color (e.g., apple can be red, green, and yellow). Or it could be that the psych-color words are special in that they tend to increase arousal level as would be produced in perceiving their associated color and such shared physiological state may function at a subconscious level and not reflected in the conscious subjective rating of their connection. So essentially the overall connection between the two, pooling both the conscious and the subconscious is stronger, which produced the larger color simulation effects observed for the words psychologically-related to color.

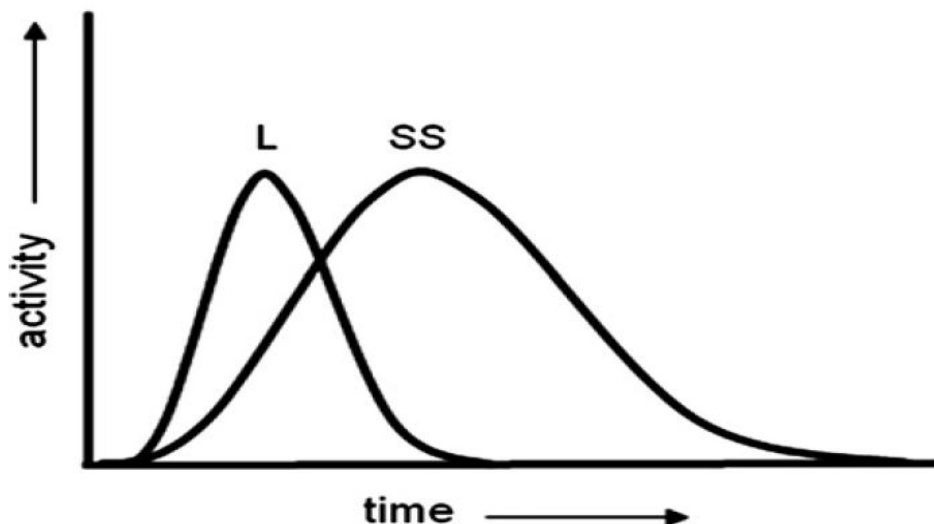
Moreover, the strong relation between color and psychological functioning has been demonstrated in some recent studies (Anis et al., 2012; Basel, 2012; Elliot et al., 2007; Hill & Barton, 2005; Mehta & Zhu, 2009). For example, Elliot et al. (2007) focused on the relation between red and performance attainment. Red is hypothesized to impair performance on achievement tasks, because red

is associated with the danger of failure in achievement contexts and evokes avoidance motivation. Their first four experiments demonstrated that the brief perception of red prior to an important test (e.g., an IQ test) impairs performance. Moreover, such influence seems to be an unconscious one. Obviously, their findings provide support to the possibility that reversely psychological-feeling words such as danger could involve color as part of the representation. Our results fit with these previous studies.

The results that color activation was the slowest for verbs, particularly slower than the color activation for object nouns, is relatively easy to interpret if we assume that for verbs, the

retrieval of associated color information depends on or is mediated by the first activation of the objects involved in the action the word refers to. The different time courses of the activation of verbs, nouns, and words psychologically-related to color seem to fit with the proposal of Simmons et al. (2008) that the contributions of perceptual simulation in conceptual processing are assumed to vary (Fig. 2). In response to different types of words, the height, width, shape, and offset of the distribution of linguistic system (L) and simulation system (SS) are likely to change. In regard to the current study, our results showed that the latency of word psychologically-related to color comes first, which in turn was followed by object noun and verbs.

Figure-2: Hypothesized contributions from the language system (L) and the situated simulation system (SS) during conceptual processing proposed by Simmons et al. (2008).



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