How "Implicit" Are Implicit Color Effects in Memory?

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Abstract. Processing colored pictures of objects results in a preference to choose the former color for a specific object in a subsequent color choice test (Wippich & Mecklenbräuker, 1998). We tested whether this implicit memory effect is independent of performances in episodic color recollection (recognition). In the study phase of Experiment 1, the color of line drawings was either named or its appropriateness was judged. We found only weak implicit memory effects for categorical color information. In Experiment 2, silhouettes were colored by subjects during the study phase. Performances in both the implicit and the explicit test were good. Selections of "old" colors in the implicit test, though, were almost completely confined to items for which the color was also remembered explicitly. In Experiment 3, we applied the opposition technique in order to check whether we could find any implicit effects regarding items for which no explicit color recollection was possible. This was not the case. We therefore draw the conclusion that implicit color preference effects are not independent of explicit recollection, and that they are probably based on the same episodic memory traces that are used in explicit tests.

Key words: implicit memory, color memory, episodic memory trace, picture memory, color preferences

In the course of the 1980s, implicit memory phenomena became the focus of psychological research on memory. If, during some experimental task, subjects are confronted with a stimulus a second time, the processing of this particular stimulus becomes faster and better. This implicit memory effect is called "repetition priming". It is not an explicit memory effect since it is independent of conscious recollection and occurs involuntarily, i.e., when subjects do not intend to retrieve anything from memory (Graf & Schacter, 1985). Facilitation is even found when subjects are not able to consciously remember the occurrence of the stimulus (see Perrig, Wippich, & Perrig-Chiello, 1993). In addition, such effects are not conceptual but perceptual in nature because implicit effects in identification are sensory specific. Changing the presentation modality between study and test makes repetition gains diminish or even disappear (see overview in Roediger & McDermott, 1993), whereas explicit performances are far less affected by such manipulations (Craik, Moscovitch, & McDowd, 1994; Madigan, 1983). This specificity is explained in terms of the transfer-appropriate processing account through the repetition of the former stimulus processing. The mentioned implicit tasks (e.g., lexical decision, identification and naming tasks) are based on perceptual information, whilst explicit remembering (recognition) should be based on conceptual information (e.g., Roediger, 1990; Srinivas & Roediger, 1990).

Later studies demonstrated, though, that this simple dichotomy – perceptual vs. conceptual – cannot be sufficient (see Engelkamp, Zimmer, & De Vega, 2000). Perceptual implicit tests are less sensory-specific than first thought. They are invariant to quite a few sensory manipulations, such as changes in size, orientation, and color of stimuli (e.g., Biederman & Cooper, 1991, 1992; Cave, Bost, & Cobb, 1996; Cooper, Biederman, & Hummel, 1992; Cooper, Schacter, Ballesteros, & Moore, 1992; Jolicoeur, 1987; Zimmer, 1993, 1995; Zimmer & Steiner, in press). At about the same time, and in contradiction to earlier claims, it was reported that changing the very same sensory features rendered episodic recognition of objects more difficult, although the features were not relevant for the decision (e.g., Cooper, Schacter, Ballesteros, &

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Moore, 1992; Jolicoeur, 1987; Zimmer, 1993, 1995; Zimmer & Steiner, in press). These findings show that in *explicit* recognition not only conceptual information is used, but that specific sensory information is automatically used as well. We assume that the explicit effects are caused by *perceptual records* of stimulus perception. Implicit effects observed in identification, on the other hand, cannot be caused by these records because otherwise all sensory features should come into effect. It was therefore presumed that *perceptual implicit effects* are based on *representations in input systems* that are responsible for the identification of objects and which merely represent prototypical features. Only when a perceived stimulus deviates considerably from the prototypical features are specific tokens re-addressed (Zimmer, 2000; Zimmer & Steiner, 2002a).

Yet there are other implicit memory effects regarding sensory features that must use perceptual information of the specific episode. Wippich and Mecklenbräuker, for instance, reported indirect effects of preceding study on color preference in a color choice test (1998; Wippich, Mecklenbräuker, & Baumann, 1994). In the test-phase subjects saw either black-and-white pictures of objects or their names, and had to spontaneously pick one out of four possible colors (color names or cards) that they preferred for the particular object. During testing, a specific color was more often assigned to an item if this item was previously presented in that color than if it was seen for the first time. Accordingly, "old" colors were chosen with a higher probability than were "new" colors.

This preference for old colors was found after naming either the object or its color (Exp. 1, Wippich et al., 1994). It occurred if a color choice took place or the vividness of the object had to be judged during study (Exp. 2, Wippich et al., 1994), but the extent of the effect changed with the task. A color choice during the study phase caused an increase of the old-new advantage from .10 to .27 compared to a judgment about vividness. Using colored words in the study and test phases made the color preference disappear completely. In contrast, a change of sensory modality from pictures to words between study and test had no influence. The repetition effect observed in identification showed the exact inverse pattern: A change in modality reduced the effect, while a change in color showed no influence (Exp. 1, Wippich & Mecklenbräuker, 1998). The authors therefore concluded that identification is a perceptual test, whereas the color choice test is a conceptual one (see also Davidoff, 1991; Paivio & Te Linde, 1980). In the following, we would like to take a closer look at this implicit effect on color preferences. In doing so we have two goals.

Firstly, we want to check how *perceptually specific* these effects are. The authors spoke of color effects, but the experimental setting suggested the processing of color names. For example, there were always only four colors to choose from (e.g., blue, green, red, and yellow), and the color choice took place, in some cases, by the naming of colors. The observed color effects are therefore based on perceptual information, but they might not be perceptually very specific. This is what we want to examine in Experiment 1.

Secondly, we would like to clarify what kind of memory traces the implicit color effect depends on and in what respect it differs from explicit memory effects. The term "implicit" is used with varying intentions, and implicit remembering is discriminated from explicit remembering on multiple dimensions. Implicit memory effects are seen as automatic (involuntary) and as unconscious (unaware). Subjects should not have *retrieval intentionality*, i.e., they do not intentionally search their memory for past experiences, but automatically reuse traces of past processing (Schacter, Bowers, & Booker, 1989). According to the *transfer-appropriate processing* (TAP) principle, this memory effect occurs because the same processing components are involved during both study and test (e.g., Roediger & Srinivas, 1993). Dissociations between explicit and implicit memory tasks should therefore occur only if both tests are based on different memory contents. This feature however makes it difficult to explain why amnesiacs can access particular memory entries implicitly, but not explicitly (see Moscovitch, Goshen-Gottstein, & Vriezen, 1994).

The difference can easily be explained by the alternative position, which postulates different memory systems (e.g., Squire, 1992). The *systems approach* assigns implicit effects to perceptual input systems in which memory traces of stimulus identification are formed (e.g., Schacter, 1994) and conscious recollection is assigned to an explicit memory system. Amnesiacs may therefore exhibit remarkable implicit but poor explicit memory performances. A systems approach however runs into problems if it is assumed that the various subsystems are arranged in a hierarchical manner, and that the perceptual input systems lie beneath episodic memory within this hierarchy (e.g., Tulving, 1984). In such a hierarchy the perceptual system is part of both processing streams, and one should therefore not observe that features processed at the perceptual level can be ignored in an implicit object test without any cost, whereas ignoring the same features in explicit object recognition causes costs (e.g., Engelkamp et al., 2000; Zimmer, 1995).

The more recent approaches therefore combine components of both models, and additionally incorporate findings from neurobiology. The *components of processing model* may serve as an example (e.g., Moscovitch et al., 1994). In this model, no uniform circumscribed storage site for memory is supposed, but rather it is assumed that human memory is distributed across multiple content-specific subsystems, each of them being processed in specific brain structures. Various "aspects" of a perceived stimulus are represented and memorized in different subsystems. Implicit memory is based solely on these (local) domain-specific representations, while in explicit memory tasks the hippocampus and some adjacent structures (e.g., Aggleton & Brown, 1999; Brown & Aggleton, 2001) come into play. Since processing within the domain specific (input) modules does not become conscious, these memory entries also remain unaware. If, however, the perceived stimulus is consciously processed during study, the hippocampal system is involved. This system binds together the various features of an object and also components from context, and an episodic memory trace is generated by this process.

According to the components of processing model, some indirect memory effects are based upon domain-specific representations that can be used independently of the hippocampal system, i.e., regardless of whether these components are explicitly accessible or not. However, indirect effects can also be based on memory traces that are bound by the hippocampus, if one allows an automatic retrieval of episodic entries. Therefore, two kinds of "implicit" (indirect) memory effects are possible: effects that are independent on the ability to recollect the item explicitly, and effects of traces bound by the hippocampus, which implies that the stimulus can also be explicitly remembered. Examples of the former case are repetition effects in identification, which probably depend on representations in sensory input modules (e.g., Schacter, 1994). Examples of the latter case are indirect sensory effects on object recognition (Zimmer, 1993). We are interested in whether the implicit memory effects in the color preference task are of the first type, and therefore independent of explicit recollection, or of the second type, i.e., based on an episodic trace that binds object and color information.

Wippich and Mecklenbräuker (1998) used quite short study lists (20–32 objects), and the interval between study and test was also short. It is therefore likely that subjects (involuntarily) accessed episodic traces of old items during test. The empirical data do not exclude this possibility. The frequencies of 'correct' old responses in the implicit task (selecting the former color) were always lower than the frequencies of correct old responses in the explicit task (see also Butler & Berry, 2001). Hence, it is possible that color choice tasks are solved by using explicitly accessible memory traces. They may be based on a subset of the items that are accessible for recollection. This idea is also supported by the finding that no changes of color preference occur if colored words are used, for which explicit color memory is generally poor. We therefore carried out another three experiments using the color choice task in order to find out whether implicit color effects are independent of explicit remembering, i.e., they appear even if subjects cannot explicitly remember the color, as was proven for a number of implicit tests (e.g., Tulving, Schacter, & Stark, 1982). Alternatively, the color preference effects could be bound to the existence of episodic memory traces, i.e., they appear only if color can also be explicitly remembered.

In Experiment 1 we tried to replicate the former findings in the first place in order to have a working basis for the following experiments, and we also examined the specificity of the effects. In Experiment 2 we took a closer look at whether the two memory measures are connected. We checked on an item basis if explicit and implicit remembering co-varied. Finally, in Experiment 3 we used the opposition technique to scrutinize whether there is an implicit color effect beyond explicit remembering.

Experiment 1

To mimic the procedure of Wippich and Mecklenbräuker (1998), our subjects saw pictures of objects, parts of which were color specific. The color of the stimulus was always task relevant in the study phase, so color was processed both during encoding and testing. In addition, we manipulated the type of encoding and length of the list in order to influence the level of memory performances. During study, the color of the item was either to be named or its appropriateness regarding the particular object was to be judged. Perceptual processing of the stimulus color is sufficient for solving the first task, but semantic processing is necessary for accomplishing the latter. Hence memory performance ought to be better following semantic encoding compared to the sensory condition. For the same reason, we used two different list lengths: a short list containing 24 items and a long one with 48 items. Both manipulations should give us an initial hint as to the contribution of explicit memory to the implicit effects. If the extent of color preferences is high in those conditions in which explicit memory is usually high, i.e., short lists and semantic encoding, and otherwise low, this would speak in favor of a contribution of explicit memory.

Finally, we changed the mode of color manipulation and color choice in order to test how specific the color effects were. To check whether (perceptual) color information can also be used, we proceeded as follows: We chose the same four basic colors that had been used before (red, yellow, green, and brown), but for each color we created three different color tones. These twelve tones could also be picked during testing. Because of this manipulation, the data can be evaluated in two different ways: One considers either only the more abstract color category (e.g., red) or the specific color value (e.g., dark red). If color preferences occur even for the particular tones, that would speak for the usage of specific color information, which is probably no longer conceptual.

Method

Subjects

Altogether 64 students of Saarland University participated in this experiment. They were paid for their cooperation. Half of the subjects were presented with short lists of 24 items, the other half with long lists of 48 items. Half of both groups named the colors; the others judged the appropriateness of the colors.

Materials and Design

Ninety-six line drawings of everyday objects were picked from the item-pool of Corel Draw 6. Forty-eight of these were color specific, i.e., they had a prototypical color (e.g., banana, strawberry). The other 48 were not color specific, i.e., they are not associated with a particular color. Apart from this, for every basic color (red, yellow, green, and brown), three color tones were chosen that belonged to these categories while being distinguishable to the highest possible degree (e.g., orange-red, dark red, carmine-red). The objects existed as line drawings showing thick black lines on a white background. These pictures were shown in their specific foreground color in the study phase. Every object was only presented in one color. The color specific objects were always shown in an appropriate color, and a color was randomly selected for the other objects. Four short lists and two long lists were constructed; the latter were two concatenated short lists. In the test lists, new items were added so that half of the items were old and half new. Across subjects it was balanced which items were old and which were new.

Due to the manipulation of encoding tasks and materials, a $2 \times 2 \times 2 \times 2$ design with the factors list length, encoding task, color specificity, and repetition (old vs. new) resulted. The first two factors were manipulated between, the last two within subjects.

Procedure

The experiment was run on an IBM-compatible personal computer using the program ERTSVIPL (Berisoft). All pictures were presented on a 17 inch screen with a resolution of 640×480 pixels in the 256-colors mode. The experiment had two phases. During the first phase, subjects were instructed to either judge the appropriateness of the color for each object (Group 1) or to simply name the color (Group 2). There were no limitations regarding the chosen color names. We gave the impression that we were interested in the time necessary for color naming. Thus, the subjects did not know about the second part of the experiment. The stimuli were presented in the middle of the screen for three seconds with one second pauses in-between.

After this encoding phase, the implicit test followed. There was no reference made to the first experiment. Subjects were told about a new experiment in which we wanted to find out something about color preferences. All objects were now shown in black-and-white and appeared individually on the screen for 1500 ms. Immediately after the onset of an object, a palette with all 12 colors appeared. The colors were arranged in a 4×3 matrix. The subjects selected the color they thought would best fit the object just presented. They made their choice by pressing the corresponding key on a keyboard. The keys were arranged in the same way as the color palette. The subjects were told to react as spontaneously as possible. Presentation was self-paced with an interstimulus interval of 500 ms.

Results and Discussion

The responses were evaluated in two different ways. Firstly, relative frequencies for selections of old colors were calculated considering the more abstract color categories. In this case, all choices from the color category of a studied item were rated "old", and the specific color tone was not taken into account. This evaluation method is similar to the one applied by Wippich et al (1994). Secondly, relative frequencies were calculated for same-color-tone matches. This measure included color tone information. In this case, only exact matches were rated "old", e.g., when a particular item was colored orange both at study and at test. In Table 1 the corresponding means for abstract color categories are reported.

An ANOVA with the four factors encoding task (2), list length (2), old-new status (2), and color specificity (2) revealed two significant effects. The "old" color was assigned to items more frequently (.56, $SE = .01$) if they had appeared in that color in the study phase than if the items were new (.51, $SE = .01$), $F(1, 60) = 8.60$, $MSE = .010$, $p < .005$. This is the expected indirect color effect. The second effect is the not surprising advantage of color-specific items as compared to color-unspecific items, $F(1, 60) = 1525.1$, $MSE = .014$, $p < .001$. For color specific

Table 1. Relative Frequencies of Selecting the "Old" Color of the Study Phase in the Color Preference Test, Dependent on List Length, Encoding Task, Item Status (Study-Test Relation), and Type of Item (Experiment 1)

	Short lists Color encoding task				Long lists Color encoding task			
	Naming Item status		Judgment Item status		Naming Item status		Judgment Item status	
	Old	New	Old	New	Old	New	Old	New
Type of item								
Color specific	.81	.82	.85	.80	.87	.82	.85	.79
Color unspecific	.24	.19	.29	.21	.23	.26	.27	.23

items, their usual color was picked again more often (old: .84, new: .81, *SE* = .01) than the study color was selected for color-unspecific items (old: .26, new: .23, *SE* = .01). All other *F* values were smaller than 1. Thus, unexpectedly, we found neither an effect of list length nor an effect of levels of processing. Changes of color preferences were small in all conditions.

However, despite the changes of color preference for old colors being small, they were statistically significant. The question now is whether this also holds true for the specific color tone? The data show that this is not the case. Taking account of the color tone, the old-new effect disappears, $F(1, 60) = .28$. The mean values for color-unspecific items (.08, *SE* = .02) are equivalent to the frequencies that would have been expected with random choice (1 out of 12). They vary between .06 and .10. For the color-specific items, the mean was .31 (*SE* = .03), which also lies close to chance level if one considers that nearly all choices referred to the three potentially appropriate colors, with values between .24 and .38. However, even the numerically higher values do not reflect color memory performance but object-specific preferences for particular colors – shades of yellow in this case. The frequencies of choosing these specific colors were the same for old and new items (.38 respectively).

We could therefore prove only a small but systematic effect on color choice. This replicates the data of Wippich et al. (1994). The effect seems to be rather categorical, though, as we could not find any advantage for the specific color tone. Because encoding task and list length exhibited no influence, this experiment disclosed no information as to whether the color effect is based on episodic memory traces or not. We believe that the very small changes of color preference are due to the clearly incidental way of studying. Our subjects did not expect to be tested or to see the items again. Under these conditions, explicit recollection of colored line drawings is poor, as we know from other experiments, and this even held true when the task explicitly required the processing of color (Zimmer, 1993; Zimmer & Steiner, 2002b). So, indirectly, the rather weak effects on color preference in Experiment 1 may indicate a contribution of episodic memory traces to the color effect. If people only show an old-new effect in color choice when they are able to remember the color explicitly as well, then changes of color preference should be small in an encoding condition that leads to poor color recollection. Wippich et al. and Wippich and Mecklenbräuker (1994, 1998) have also found small color effects or none at all with an item class for which explicit color memory is also poor: colored words.

Thus, the first experiment replicated the findings of Wippich et al., and it additionally demonstrated that the effect could not be found for the specific color tone. However, it did not say anything about the type of memory trace that was used in the task. That is why another method was chosen in the following experiments.

Experiment 2

First of all we searched for a method to examine whether performances in the implicit and explicit color choice tests are mutually dependent. If the same memory entries are accessed and used in color choice and explicit recollection, the same items should be processed with or without success in both tasks. If an item is associated with its study color in memory and one uses this trace in color choice, one should also be able to access it in the explicit test. On the other hand, if such an association does not exist, one should not be able to remember the color explicitly either. Thus, the solution probabilities in the two tasks should strongly correlate across items.

In this experiment our subjects therefore first performed an implicit color choice task followed by an explicit one. In both tests, the same items were presented. The repeated testing harbored the risk of unwanted carry over effects, but that could not be avoided because we needed the performance data of every subject on both tasks for every item. Potential testing effects are nevertheless of minor importance for the interpretation of the color specific results, since in the implicit test all items are presented in black and white. The implicit test therefore does not represent a new study trial as far as color is concerned.

Significant coherence between the tests can nevertheless only be expected if there are sufficiently large changes of color preference in the implicit test – clearly larger than those in Experiment 1. For that reason, we tried to improve implicit memory performance. To achieve this, we presented colored silhouettes instead of line drawings and the appropriate color should have already been selected at incidental study. Under these conditions, the preference to choose an "old" color should increase. Apart from that, we only used color-unspecific objects to avoid ceiling effects. Finally, we used no more than four colors, since no color-tone specific effects occurred in the first experiment.

Method

Subjects

Twenty-four students of Saarland University participated in this experiment. They were paid for their co-operation, and none of them had taken part in Experiment 1.

Materials and Design

We used the pictures of color-unspecific objects from the first experiment. The original line drawings were transformed into silhouettes. For this purpose the line drawings were fully filled with the foreground color, namely black. In the study phase, black was replaced by one of the four colors when a subject had selected the preferred color, so that the whole surface of the objects was shown in color after this change in the presentation.

The items were randomly distributed into 6 groups, each containing 8 items. Three groups (24 items) were shown at study; and the three remaining groups were then presented as new items in the implicit test. Altogether six different study lists were composed by rotating the groups selected for study. At test all items were presented so that in the implicit test half the items were old, half new. In the explicit color test, only old, black items were shown. Between the explicit and implicit tests, therefore, only the test instruction varied. Across subjects, the lists were balanced, so that all items were used equally as old and new items.

Procedure

The experiment was run on an IBM-compatible personal computer using the program ERTSVIPL (Berisoft). All pictures were presented on a computer-screen with a resolution of 640 × 480 pixels in 256 color mode. The experiment consisted of three phases: encoding phase, implicit color choice test, and explicit color test. During the encoding phase, subjects saw black-and-white pictures one by one. They were instructed to assign an appropriate color to every single picture by pressing one of four keys labeled with colored stickers in red, green, brown, and yellow, respectively. When they pressed one of the keys, the object was colored in the according color and remained that way on the screen for 4 seconds. After each trial, there was a pause of one second. The implicit test followed the encoding phase. The instruction and presentation stayed the same, except that the item was not again shown colored. The interstimulus interval was one second.

Finally, subjects performed an explicit color choice test. All items of the implicit test were shown again, i.e., all old pictures from the study phase *and* all new ones from the test phase. The objects again appeared successively in black and white on the screen. Subjects first decided whether they had already seen the presented item in the first phase of the experiment or if it had only appeared in the second. Thus, the first task was source discrimination. Then they tried to remember the color that the particular object had had. If they thought the item originated from the first phase, they assigned the according color to it; if they thought it originated from the second phase, they assigned the color they had selected for that item in the second phase. Like in the implicit test, the item disappeared as soon as subjects remembered a color and pressed a key. After a pause of one second, the next picture appeared.

Table 2. Relative Frequencies of Selecting the Old Colors in the Implicit Color Test (Color Preference) for Old Items, and in the Explicit Color Recognition Test, Dependent on Study Test Relation. (Experiment 2)

	Color			
	Yellow	Brown	Red	Green
		Implicit test		
Item status				
Old items	.80[1]	.73	.76	.72
New items	.17[2]	.34	.26	.20
		Explicit test		
Item status				
From study phase	.82[3]	.75	.77	.76
From implicit test	.72[3]	.81	.66	.69

Note. The figures for new items give the frequencies of selecting this specific color at first presentation. [1]Relative frequencies of selecting this color at test if it was already used at study. [2]Relative frequencies of selecting this color if the item was seen for the first time. [3]Relative frequencies of correct color choices in the explicit color recognition test for items that first appeared in the study or test phase.

Results and Discussion

As in the first experiment, we checked the memory performances for color in the implicit test first. For this purpose, we determined the portion of items that were colored in their study color by the subjects at the time of their second presentation. Because subjects could select the colors for the items without any restrictions in the encoding phase, the absolute frequencies of the 4 colors in the study phase were not equal. We therefore related the frequencies with which the individual colors were selected at test to the frequencies with which the specific colors were chosen by a particular person for the items at study. For instance, if a subject had assigned the color yellow to six objects at study and selected yellow for five of these objects at test, the relative frequency for the "old" color was 5/6 (.83). Table 2 shows the according frequencies of choosing a particular color for all four used colors and for old and new items separately.

The frequencies with which the single colors were assigned to new items disperse around the chance level of .25. Thus, there is no preference for a particular color if color is assigned to an object for the first time. For old items, however, in most cases the study color was chosen. The mean value across all colors was .75, $SE = .04$. In other words, subjects' tendency to color old objects with the same color with which it had been presented at study occurred well above chance. Thus, the effect of the preceding study phase on the implicit color choice (.50) was, as expected, clearly larger than in Experiment 1.

We then inspected whether subjects were able to distinguish the phases in the explicit test. The performance in this source discrimination task can be interpreted as an indicator of conscious recollection (see Buchner, Erdfelder, Steffens, & Martensen, 1997). Subjects did quite well on this task. Seventy-seven percent ($SE = .05$) of phase 2 items and eighty-nine percent ($SE = .04$) of items first encountered in phase 1 were correctly classified. Both values lie clearly above chance. At the same time, performance for the repeated items of phase 1 was better than for the items of phase 2 that were only seen once; $t(23) = 2.48$, $p < .05$. Thus, subjects seem to have quite good explicit memory for the items, if one interprets contextual embedding as a sign of conscious recollection. This context knowledge was more marked for the "old" items, although these items appeared in both phases. This should actually make the decision whether an item had already appeared in phase 1 or only in phase 2 harder compared to a judgment about items that were only presented in phase 2, presupposing each presentation caused an independent memory trace. The fact that old items had an advantage indicates, in our opinion, that the presentation of an item in the implicit test addressed the memory trace of that item formed in the study phase, so that no new memory token was set up but an old one reactivated.

We then evaluated the explicit test the same way we evaluated the implicit. In the explicit test, color memory performance was also good. Items of the study phase were given their "correct" (former) color in 78% ($SE = .03$) of cases, and even for the new items of the implicit test the "correct" color was remembered 73% ($SE = .04$) of the time. The hit rates for the two phases did not differ significantly, $F(1, 18) < 1.87$, $p = .18$. These data clearly demonstrate that our procedure causes good explicit color memory, as intended.

The interesting question next was the extent to which the performances in the implicit and explicit test covariate. For this purpose, we correlated the performances in both tasks across items. We found a high correlation between memory performances in the implicit and explicit tests, $r\ (N = 48) = .86, p < .05$. That means that subjects remembered (or couldn't remember, respectively) the colors of the same items in both the implicit and the explicit tests. Counting color and item memory for subjects, it turned out that the study color of 61% of old items was remembered in *both* tests. That means for 81% of the items that were "correctly" colored by subjects in the implicit test, the correct color was also remembered in the explicit test. Cases in which the choice was right in the implicit but wrong in the explicit test were quite rare (9%), as was selecting a wrong color in the implicit test while the correct color was picked in the explicit test (6%). Subjects sticking to the wrong color of the implicit test in the explicit test was as frequent as the opposite case, that a wrong color was changed into another wrong one (12%). These figures lie close to the value (10%) that would be expected if subjects randomly assigned a color to the remaining 40% of items they could not remember the color of.

We interpret the fact that color preference is almost completely due to items for which color could also be remembered explicitly as proof for the assumption that the same memory traces that are used in the explicit test are also accessed in the implicit test. Such correlative findings are of course only indicative, but the interpretation in terms of usage of the same memory traces seems more plausible to us than alternative explanations. We think two alternatives are especially critical, so we would like to discuss these separately.

First, the data could reflect neither explicit nor implicit memory performance, but stable color preferences for the objects. In the implicit test and the study phase, subjects assigned a color to an object that seemed most appropriate to them. If subjects constantly preferred one color for a particular object, despite the fact that objects were not color-specific, that would cause subjects to select the same color at both presentations. We consider this possibility unlikely. All items also appeared once as new items in the implicit test. It would be quite a coincidence if existing individual color preferences were distributed across the four colors in a way that frequencies, on average, would again resemble a chance distribution. We therefore think that the effects are episodic and were generated by the color assignment at study.

Another critical alternative would be that the dependence of the two tests was only artificially created by the experimental manipulation, e.g., by testing the same items twice. The colors chosen in the implicit test may have been remembered in the following explicit test. Such an effect would increase the tendency to assign old colors to old items, if the old color had already been selected in the implicit test, and, on the other hand, "new" colors should have prevailed in the explicit test, if the old color had not been memorized. However, there are also no indicators of this. Items that got a "new" color in the implicit test disperse relatively equally on the given possibilities of color assignment in the explicit test, which speaks against an automatic preference for the implicitly selected color. Apart from that, the colors of the new items of the implicit test were remembered in the explicit test just about as well as the colors of old items. Whether between study and test phase items are processed a second time or not, therefore does not seem to influence color memory – remembering that the items were always presented in black and white during testing.

Experiment 3

Because of the considerations pointed out above, we interpret the results of Experiment 2 as proof of the assumption that the same episodic traces are accessed in both the implicit and explicit test. In order to gain further evidence supporting this supposition, we carried out a third experiment in which we used a different technique to test whether implicit memory effects could occur independently of explicit recollection.

For implicit and explicit performances, stochastic independence was found (e.g., Mitchell & Brown, 1988; Tulving et al., 1982). Implicit memory effects were just as large for items explicitly recollected as for items not explicitly remembered. If this is the case, it speaks well for implicit performances being based on other memory processes or traces than the explicit ones. One can directly test this idea that implicit effects should occur even if nothing can be explicitly remembered, by bringing explicit and implicit memory processes into opposition to each other (see Jacoby, Toth, & Yonelinas, 1993). We did this by prohibiting the use of explicitly remembered alternatives as solutions for the implicit task (see Richardson-Klavehn, Gardiner, & Java, 1994). Subjects were told to explicitly remember the color of an item first and then to select a preferred color from the remaining ones for the same item. If the real "old" color is not selected in the explicit test, it is still among the remaining alternatives to be picked from. Now, if there is independent implicit remembering in addition to explicit remembering, the correct alternative should be selected above chance in this implicit choice task, despite no explicit remembering being possible. But, if no implicit memory effect becomes effective beyond explicit recollection, all alternatives should be equally probable. This is the technique we used to examine implicit color effects.

As in the first experiment, subjects incidentally studied colored objects, but in this experiment the colors were randomly selected by the experimenter. Thus, personal color preferences could not be a reason for any implicit color effect. For reasons of distraction, subjects had to name the objects during study. We decided on a naming task in this experiment instead of the color choice task used Experiment 2 in order to avoid ceiling-effects in explicit color memory. In this experiment, it was important to attain mid-level color memory performance. Of course, color should be remembered above chance so we could assume that color was actually encoded at all, but still there should be enough cases where color is not remembered explicitly and so the possibility remained to select the "old" color solely implicitly without having remembered it explicitly before. If there is an implicit color effect going beyond the cases where colors can be remembered explicitly, then there should be a preference for the old color in cases where *no* explicit recollection was possible. Hence, the interesting cases are those in which subjects select a wrong color in the explicit part or state that they cannot remember. For these cases, we wanted to check whether there would nevertheless be an implicit preference for the old color. It was not apparent to subjects whether they had correctly remembered the former color or not, since they were not given any feedback about their responses.

Method

Subjects

Sixteen students of Saarland University took part in this experiment and were paid for their cooperation. None of them had participated in any of the other experiments.

Materials and Design

Altogether 96 noncolor-specific objects were used. Forty-eight of them stemmed from the second experiment, the other 48 were newly selected from the Corel Draw Clipart set. They were all line drawings filled with one of the four colors, like in Experiment 2, so that silhouettes resulted. From these items, two sets of four study lists were composed with 48 items each. Across the 4 lists, the colors of items were counterbalanced within a set. Apart from that, there was a test list comprising all 96 items, so that half of the items were old and the other half new, respectively. The whole variation therefore occurred within subjects. The assignment of items to conditions was counterbalanced.

Procedure

First, subjects incidentally studied one of the lists. The colored pictures appeared one by one on the screen for 2 seconds, and the task was to name the depicted object. After each item, there was a pause of 500 ms.

In the subsequent test, subjects saw black-and-white objects on the screen. The presentation of items was self-paced. First, they assigned the color from the study list to the object, if it was an old one, by pressing a colored key on the keyboard. If they could not remember the color, or if it was a new item, they pressed a fifth key for "unknown". They had 8 seconds at most to react. After this explicit color choice, they made a second preference decision. They were instructed to assign one of the *remaining* colors to the object, namely the one they thought was most appropriate. Thus, they were not allowed to select the color they had explicitly remembered before a second time. Again, the maximum reaction time was 8 seconds. After a pause of 1 second, the next object appeared.

Results and Discussion

To measure explicit color memory performance, the number of correct color responses was divided by the total of all items. The mean color recollection rate was .44, SE = .04. This performance definitely lies above the chance level of .25, but it still leaves enough room to determine implicit effects for colors not explicitly remembered. The rate of incorrectly remembered colors was .30, for "don't know" answers, .27.

In the implicit test the frequencies of correct responses, i.e., choosing the "old" color, was divided by the number of possible cases, i.e., the sum of incorrect responses and no responses in the explicit test. If the color was remembered incorrectly in the explicit test, the study color was selected in the implicit test with a frequency of .31. This did not differ from the chance level (.33), because there were only three colors left to choose from – the explicitly remembered color was no longer available. The same holds true for those items to which no response was given in the explicit test (unknown). The rate of "correct" choices was .27, with the chance level being .25 – in this case there were still 4 colors to choose from.

These results clearly show that there were no preferences for "old" colors in the implicit test, if a wrong color was chosen or no choice was made at all in the explicit test. In other words, if no explicit color recollection was possible, there was also no longer an implicit effect. In our opinion, this indicates that the same memory entries are accessed in both the implicit and the explicit test. It could be assumed that the color effects found in other experiments may have as well come about through the accessing of episodic memory traces,.

General Discussion

Implicit effects concerning sensory features, such as size, orientation, or the color of a picture, have yet been rarely reported. One of the few exceptions is the experiments of Wippich et al. and Wippich and Mecklenbräuker (1994, 1998). The authors used a color choice test in order to prove the existence of implicit color effects. Subjects saw uncolored objects and had to select a color that they thought was most appropriate for the particular item. Pictures that subjects had already seen in a colored version (in the study phase) were more likely to be colored in that “study color” again at test. The aim of our experiments was to test to what degree these implicit effects are bound to explicit color recollection.

In the first experiment, we used colored line drawings. There was a significant but very small effect of the preceding encoding on color preference, if subjects only took the basic color categories into account. In the second experiment, we used silhouettes that were colored by subjects during study in the color they preferred. In the unexpected test, they first had to make an implicit decision (color choice) and, in a second phase, an explicit one (color recognition). We detected a marked preference for the old color in the implicit test, as well as very good explicit color memory. Comparing for which items these performances were achieved, we found that the two testing conditions strongly correlated. Furthermore, the implicit effects were almost completely based on items for which later on the color could also be remembered explicitly.

Finally, in the third experiment we tested whether there still was a color preference to be found regarding items for which no explicit color recollection is possible. Colored silhouettes were presented that were incidentally studied by way of object naming. At test, subjects first made an explicit color decision and then took the implicit color choice test, but they were not allowed to pick the explicitly remembered color again. We received correct explicit color memory performances at around about 50%. In the implicit test, however, there was no color preference for the remaining 50% of items, for which the color could not be remembered explicitly.

Looking at the whole of the data, a clear dependence of implicit memory on explicit performances becomes evident. This connection was clearly shown within Experiment 2, in which a covariation of implicit and explicit performance was proved on an item basis. This was additionally substantiated across experiments. When explicit memory performance increased, so did the implicit effects. This already held true for the data of Wippich et al. and Wippich and Mecklenbräuker (1994, 1998). Color choice effects occurred for pictures but not for words, and explicit color recollection showed the same differences. Finally, we showed that there were no effects of color preference if an explicit recollection of color was not possible (Exp.3). Altogether, this indicates, in our opinion, that the implicit effects occurring at color choice are based on the same memory traces that are used in explicit tests.

These implicit effects are therefore “implicit” in a different way than are the implicit effects in object identification. Repetition effects in object identification are independent of explicit remembering (see Schacter, Delaney, & Merikle, 1990); the implicit effects in the formation of color preferences apparently are not. The color effects are, of course, indirect memory effects, because subjects were not explicitly told to remember the objects and their colors, but it seems as if these implicit memory performances can only be achieved if an explicit recollection was also possible. Assuming our subjects complied with the instructions, made their decisions spontaneously, and did not try to explicitly access a memory entry – an assumption supported by the data of Wippich et al. (Exp.2, 1998) – then color effects are involuntary memory effects that come about by access to an episodic token. If such a token is not accessible, however, the “implicit” color effects are missing as well.

We can therefore make out three different kinds of indirect memory effects:

(1) Effects that automatically appear if already encountered items are processed anew, no matter whether the particular item can be recognized in an episodic test or not. Object repetition effects in perceptual tasks are an example hereof. These effects are probably based on representations in a visual entry system (see Schacter, 1994). As these systems are cognitively impenetrable, they are not sufficient for explicit recollection (see Moscovitch et al., 1994; Schacter & Tulving, 1994)

(2) Indirect effects that occur involuntarily when performing some sort of task, likewise without any intention to remember, and that require access to memory entries also used in explicit recollection. In our opinion, color preference effects belong to this category. We assume these effects are based on the same representations that are the basis for explicit judgments.

(3) Finally there are indirect memory effects that can only be found in the context of voluntary epi-

sodic retrieval. These effects occur involuntarily, too, but they show up in explicit tasks with retrieval intention. Sensory congruence effects in object recognition are of this kind (e.g., Zimmer, 1995).

Whether this binding of implicit and explicit remembrance is specific to color is yet not clear. It seems possible that color and shape are *two* independently analyzed features that need actively to be integrated in an episodic token to be memorized together at all (see Chalfonte & Johnson, 1996). Such feature binding could require the participation of specific processing systems or components, and these could be the same components that make explicit recollection possible. Moscovitch proposed that "the hippocampus binds or integrates the engrams of the modules and central systems … The resulting collection of bound engrams constitutes a memory trace … To recollect a recent event consciously, a memory trace must be reactivated via the hippocampal component. This occurs when an external" cue automatically triggers the hippocampal index- (Moscovitch, 1992, p.260). If the hippocampus plays this common role in the encoding of color and shape on the one hand and in explicit recollection on the other hand, the mutual dependence of implicit and explicit memory regarding the color effect becomes intelligible. Possibly this also holds true for other sensory features. At least in one experiment it was reported that amnesic patients with imputed damage to the hippocampus did not show effects of sensory study-test congruence in implicit word priming, whereas healthy subjects – as usual (see Tenpenny, 1995) – did (Kinoshita & Wayland, 1993).

Two types of color effects in implicit memory tests therefore exist. We know of perceptual item-specific tests which make necessary the identification of objects and which depend on the exact repetition of the object's shape. These tests are independent of explicit recollection (Moscovitch et al., 1994), and in these tests there are usually no color specific effects (Cave et al., 1996; Zimmer, 1993; Zimmer & Steiner, in press) or they only appear under very specific conditions (Zimmer & Steiner, 2002a). Contrary to that, in the implicit color choice test indirect color effects occur (Wippich et al. and Wippich and Mecklenbräuker, 1994, 1998), but this effect depends on the fact that color can be explicitly recollected too. We therefore assume that color preference effects, though obtained in an indirect test, are based on the same traces and use partly the same structural network that are also used in explicit recollection.

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