한국심리학회지 : 인지 및 생물
The Korean Journal of Cognitive and Biological Psychology
2012, Vol. 24, No. 3, 281-293

The Effects of Task-irrelevant Color Uniformity in Attentional Blink*

Jangjin Kim
Center for Human Behavior
Yonsei University

Min-Shik Kim†
Department of Psychology
Yonsei University

In searching for targets among a rapidly presented stream of distractors, correct identification for the first target impairs the detection of the following one appearing within a half second after the first one appeared: the attentional blink (AB). Di Lollo and his colleagues (2005) proposed that temporary loss of control of the exogenously-triggered input filter explained the AB: They showed that AB was apparent when a nontarget category item was put in the target string, but diminished when the target string consisted of the same category items. We examined whether the AB effect is also affected by disrupting the uniformity of the online-established, task-irrelevant dimension. In the current study, we manipulated the uniformity of the task-relevant, target-defining dimension (category), following the previous study by Di Lollo et al. as well as the uniformity of the instantly obtained, task-irrelevant dimension (color). The results showed that both task-relevant and task-irrelevant uniformity modulated the AB effects. However, the results also showed that task-relevant category uniformity majorly determined the AB effects and task-irrelevant color uniformity was not able to reduce AB when category uniformity was disrupted.

Key words : attentional blink (AB), temporal visual process, category uniformity, perceptual uniformity, task-irrelevancy

---

* This research was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2012R1A2A2A01015809). We thank Kyung Bo Seo and Ji Hyun Kim for their assistance in preparing the manuscript.

† Corresponding author : Min-Shik Kim, Department of Psychology, Yonsei University, Seoul, 120-749, Korea. Email: kimm@yonsei.ac.kr

The effects of task-irrelevant color uniformity in attentional blink

When required to report two targets among sequentially presented distractors, the cognitive system suffers remarkable limitations in identifying the second target (T2) which followed the first one (T1) within 500 ms: the attentional blink (AB). There have been multiple attempts to account for the AB results. Especially, two major accounts are suggested to explain the AB: the interference model and two-stage model. The interference model explained the AB in terms of the interferences in retrieval of the targets after the selection of both targets and their temporally proximal distractors (Raymond, Shapiro, & Arnell, 1992, 1995; Shapiro, Raymond, & Arnell, 1994). Shapiro and colleagues showed that the AB effects were determined by whether or not the T1 + 1 (the distractor stimulus appeared *right after* the first target) was similar to the targets. When T1 + 1 was dissimilar to the targets, the AB effects were diminished because dissimilar T1 + 1 could be more easily figured out in the retrieval processes and resulted in less interferences. However, when T1 + 1 was similar to targets, further identification, resource-consuming process, was required for successful retrieval of targets from visual short-term memory (Shapiro & Luck, 1999). The other account regarded the limits in the consolidation process as the main cause of the AB. The two-stage model argued that a failure to consolidate the T2 in the second capacity-limited stage which already occupied by the T1 explained the AB effects (Chun & Potter, 1995). Conversely, this study suggested that when there is enough time to finish the consolidation of T1, T2 can be successfully consolidated and be ready for the conscious reports. Some electrophysiological evidences using the event-related-potentials (ERP) technique gave support to the claim that limits in consolidation processing explains the AB effects. Shapiro and his colleagues revealed that N400 waveform, the late ERP component charging the later processes in working memory, were elicited even when T2 was not successfully reported (Luck, Vogel, & Shapiro, 1996; Shapiro, Arnell, & Raymond, 1997). Their results suggested that insufficient consolidation at a post-perceptual stage of processing made a loss of T2 information and supported the claim that the consolidation process is crucial in explaining the AB effects. Although above two major accounts differ to each other in details, all of these studies uniformly regarded that resource limitations in the post-perceptual processes as the main source of AB.

Recently, however, Di Lollo and colleagues (Di Lollo, Kawahara, Shahab Ghorashi, & Enns,

2005) showed the results that cannot be explained by neither the interference model nor the two-stage model. In their study, Di Lollo et al. manipulated the T1 + 1 item so that T1 + 1 either belonged to the target category (uniform condition) or to the distractor category (varied condition). In their manipulations, the target string (consist of T1, T1 + 1, T2 in a serial order) had either three same category target items or two target category items and one interleaved non-target category item. The task was to report all the presented digits or letters among the letter- or digit-distractor stream. If the resource depletion in the post-perceptual process is the main loci of the AB effects, the AB would be more apparent in the uniform condition because there are more retrieval interferences caused by the similar items in the uniform condition as well as more severe resource shortage caused by more to-be-reported items. However, the results of Di Lollo et al. showed that the AB was diminished in the uniform condition, not in the varied condition. Instead of focusing on the resource depletion models, Di Lollo et al. turned their attention to the task-set reconfiguration (TSR) cost (Monsell, 2003). Based on TSR account, they assumed that attentional, but volatile input filter governs temporal object processing and this volatile attentional input filter is maintained by the endogenous control signals from the central processor. The endogenous signal controls the input filter well in filtering out non-targets until the selection of the T1. While T1 is processed, endogenous signal temporarily loses their controls for the input filter (temporary loss of control, TLC) and this results in that the input filter is governed by exogenous signal from the trailing T1 + 1. During that interim, if the T1 + 1 is from the non-target category, it exogenously interferes target-monitoring mechanisms and it takes the mechanisms several milliseconds to reconfigure its task-set function (TSR cost). If T2 is presented before the reconfiguration, the input filter blinks the T2 and resulted in the AB effects. As explained above, the previous study by Di Lollo et al. (2005) proposed that TLC model explains the AB effects.

The previous study by Di Lollo et al. (2005) demonstrated that the disruption of the pre-defined category uniformity in the target string impaired the processes for the trailing items, and which resulted in the AB effects. Based on Di Lollo and colleagues' findings, we examined whether the AB effect was dynamically affected by instant bottom-up information too. Specifically, the current study examined whether the disrupted uniformity of online-established, task-irrelevant dimension induced the TSR costs as well as the disruption of pre-defined dimension does. In this study, eight digits (from 2 to 9; 0 and 1 were excluded due to their shape similarities to alphabet O and I) were used as targets and 24 uppercase letters (all alphabet letters except O and I) were used as non-target distractors. We randomly selected digits and letters to compose the rapid visual presentation (RSVP) stream (see *method* for more details). As in the earlier study by Di Lollo et al., the target string had either three different digits (category-uniform) or two digits with an interleaved letter (category-varied). To assess instant bottom-up uniformity effects, all digits and letters in RSVP stream appeared in two different colors (red and green). In color-uniform condition, items in the target string were colored using either red or green only. On the contrary, in color-varied condition, one different color was used for the item which was in the middle of the target string. It should be noted that color was fully task-irrelevant in the current task. Two different colors were equally used in the target string and color neither predicted the location of the target string in the RSVP nor the identities of the targets. Participants were asked to report all the presented digits among letter RSVP stream and even they were not informed about the color. Both category and color uniformity were randomly intermixed within a block in a counter-balanced manner.

Earlier studies of the object-based attention suggested that when visual system attended an object, the features of the attended object are selected together because attention was automatically spread within the object (Duncan, 1984; Egly, Driver, & Rafal, 1994). In addition, some studies also argued that once attended dimension of one object provokes the selection of the same dimension on other objects for some milliseconds and the selected non-targets can use processing resources to the same degree as the targets when the strict target-selection criteria does not exist (Ward, Duncan, & Shapiro, 1996, 1997). Also, Kim and Cave (1999) demonstrated that attentional selection was driven to the location which contains the target 's features, even the target's features were not pre-defined and task-irrelevant. Taken together, it is highly possible that task-irrelevant color would be selected together while the input filter selects the T1. We tested whether the disruption of this online established, task-irrelevant color uniformity would affect AB effects as the disruption of target defining category uniformity did in the earlier study (Di Lollo et al., 2005) (Experiment 1).

Methods

Participants. Twenty-four undergraduate students at Yonsei university, participated for course credit, after giving informed consent. All participants reported that they had normal or corrected-to-normal visual acuity and normal color perception. None of the participants were aware of the purpose of this experiment.

Equipment. All participants were tested individually in a dimly lit room. The experiment was conducted on a Pentium-IV computer, which was controlled by programs written in Matlab with Psychophysics Toolbox extensions (Brainard, 1997). At a strict viewing distance of 57 cm, set by a chin rest, all stimuli were presented on a 17-inch LG Flatron CRT monitor with a 75-Hz refresh rate (13.3 ms/frame).

Stimuli. The size of the letters and digits was about 0.5° x 0.6° in visual angle. Digits were used as target stimuli and uppercase letters were used as non-target stimuli. Digit "0" and "1" and uppercase letter "O" and "I" were excluded to avoid confusion. Both digits and letters could have either red or green colors produced by RGB permutations. Each stimulus was exposed for 26.6 ms with an inter-stimulus interval of 65.7 ms, producing a presentation rate of 10.8 stimuli per second. All stimuli were presented in the center of a uniform gray background.

Design and Procedure. Factorial design was used for the experiment. Categorical uniformity (category-uniform vs. category-varied) and color uniformity (color-uniform vs. color-varied) were intermixed within a block. As in the previous study by Di Lollo et al. (2005, Experiment 1a), randomly ordered uppercase letters constituted the basic stream and no letters were repeated during each stream. The letters were randomly colored by either red or green. According to the categorical uniformity condition, either three digits (category-uniform condition) or two digits and an interleaved letter (category-varied condition) made up a three-item target string. In addition, the target string had either the same color (e.g., three reds; color-uniform condition) or two (e.g., two greens and an interleaved red; color-varied condition) according to the color uniformity condition. Note that the letters were randomly colored, so color predicted neither the digit target identities nor the target position in the stream: color was not a pre-defined target dimension but online-established one. To give a temporal jitter for the target position, the three-item target string was inserted either 4 or 8 or 12 letters after the first letter. The stream ended with the letter which masked the last digit (T3). All these manipulations resulted in 12 trials per block and this was repeated 12 times, resulted in an overall 144 trials.

The experiment was self-paced and was initiated by pressing the space bar. As in Di Lollo et al. (2005), participants were asked to report all presented digits (3 for category-uniform and 2 for category-varied condition, regardless of color uniformity) in each trial as accurate as possible, in any order. The percentage of correct identifications of the first and the last digits were the dependent variable.

Results

Mean percentages of overall correct responses for the targets (T1 and T3 collapsed) in each uniformity condition were calculated. In category-uniform-color-uniform condition, the mean percentage was 75.35% (*S.T.E.* ±1.41). In the other conditions, category-uniform-color-varied, category-varied-color-uniform, and category-varied-color-varied, the mean percentages were 72.63% (*S.T.E.* ±1.29), 72.74% (*S.T.E.* ±1.41), and 71.12% (*S.T.E.* ±1.43), respectively. Two-way analysis of variance (ANOVA) with category and color uniformity as factors showed that there were not any significant effects (all Fs < 2.46, all ps $> .12$). The results indicate that participants performed the task similarly across the different conditions, so any observed difference would not be contributed to mere deficit in certain conditions.

Next, the mean accuracy rates in category and color uniformity conditions as a function of the position in target string were calculated (Fig. 1A). In category-uniform-color-uniform condition, the participants reported the last target (T3) as well as the first one (T1). However, when color in target string varied, T3 report accuracy slightly dropped compared to T1 although the category uniformity was kept the same. When category varied in target string, T1 report accuracy increased but T3 report accuracy was severely impaired regardless of whether color varied or not in target string. The interpretations were confirmed by repeated-measures ANOVA using category and color uniformity as factors. The statistical results showed that there were main effects of color uniformity, $F(1, 23) = 7.13$, $p < .05$, $\eta^2 = .24$, and position in target string $F(1,23) = 30.81$, $p < .001$, $\eta^2 = .57$, as well as marginally significant effects of category uniformity, $F(1,23) = 4.14$, $p = .054$, $\eta^2 = .15$. These main effects confirmed that the accuracy rates were higher in uniform conditions than in varied conditions and T1 was better identified than T3. The ANOVA also revealed statistically significant interaction between category uniformity and position in target string (Fig. 1B), $F(1,23) = 33.28$, $p < .001$, $\eta^2 = .59$, and between color uniformity and position in target string (Fig. 1C), $F(1,23) = 5.40$, $p < .05$, $\eta^2 = .19$. Neither the three-way interaction nor the two-way interaction of categorical uniformity and color uniformity and color uniformity was significant, all Fs < 1, *n.s.* The significant interaction between category uniformity and position in target string indicated

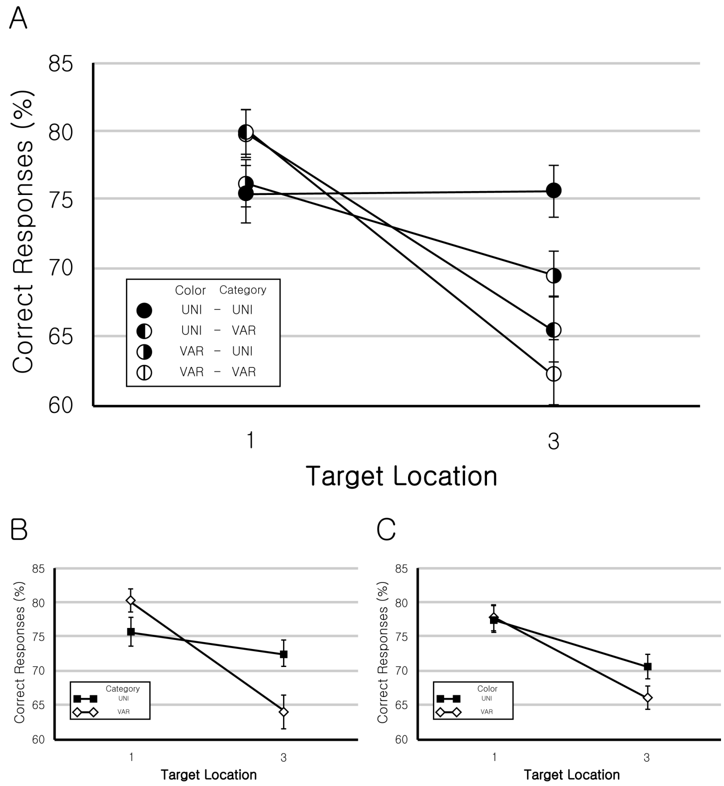

Figure 1. The mean percentage of correct responses for T1 and T3

Regardless of color-uniformity, the number of to-be-reported digits in the target string was three in category-uniform (UNI) condition and was two in category-varied (VAR) condition. In category-varied condition, two digits and one interleaved letter made up the target string. Panel A shows the mean percentages of correct rates for T1 and T3 with categorical uniformity and task-irrelevant color uniformity as factors. Panel B and C show the collapsed mean percentage of correct responses for the T1 and T3 in terms of category uniformity and task-irrelevant color uniformity, respectively. The error bars represent standard errors.

that the current study replicated well the earlier study by Di Lollo and his colleagues (2005). In addition, the significant two-way interaction between color uniformity and position in target string strongly indicated that task-irrelevant color uniformity was able to reduce AB effects, similar to task-relevant category uniformity. However, not any other significant interactions suggested that instant task-irrelevant uniformity cannot override the AB effects when target-defining category varied in target string.

It is worth to note that the magnitude of AB effect (the performance difference between T1 and T3, according to Di Lollo et al., 2005) was graded across uniformity conditions. In category-uniform-color-uniform condition, report accuracy of T1 and T3 did not differ and the difference was about 0%. When category varied (in category-varied-color-uniform and category-varied-color-varied conditions), the difference was more than 14.5%. When only color information varied in target string (category-uniform-color-varied), the difference was approximately 6.2%. Although there were neither category x color nor category x color x target string significant interactions, the results provoked the possibility that the lack of significant interaction between color and category might be due to the flooring effects. In other words, it may be possible that T3 report accuracy in category-varied-color-varied could be worse than the current performance level. The larger variances (standard error) observed in category-varied conditions (2.31% and 2.34% in category-varied-color-varied and category-varied-color-uniform condition, respectively) than in category-uniform conditions (1.67% and 1.82% in category-uniform-color-uniform and category-uniform-color-varied condition, respectively) might support this speculation. A more rigorous experiment controlling the flooring effects would verify any possible interaction between task-relevant category uniformity and task-irrelevant color uniformity.

Discussion

The interaction between category uniformity and position in the target string (Fig. 1B) perfectly fits with the results of previous study (Di Lollo et al., 2005), indicating that the accuracy rates for T3 were better in category-uniform condition than in the category-varied condition. Most importantly, the significant interaction of color uniformity and target position (Fig. 1C) confirmed one of the main concerns of the current study: AB effect was affected by the instant, not pre-defined, target dimension's uniformity. For example, task-irrelevant and instantly established color of T1 affects the selection of the following T1 + 1 and T2, depending on their colors. If T1 + 1 and T2 shared the same color with T1, the selection of the trailing items would not require TSR cost. However, variation of the color in the target string impaired the selection, so TSR costs were induced. This color uniformity effects cannot override the categorical uniformity effects. Even if the color was uniform in the target string, once the category varied, the obvious AB effects were observed. Only when category was uniform in the target string, variable colors in the target string determines the AB effects.

TLC model (Di Lollo et al., 2005) focuses on the volatile characteristic of the endogenous input filter in processing the RSVP items. The endogenous input filter successfully filters out the non-categorical items before it starts to process the first target item. Once the input filter is occupied by T1, exogenous control replaces the previous endogenous control and the input filter receives the following items without categorical filtering. Depending on the post T1 items category, task-set should be reconfigured to process the items and the changing cost or reconfiguration cost of task set (TSR cost) explains the AB effects in TLC model. In the current study, we tackled the volatile aspect of endogenous input filter by manipulating the task-irrelevant color dimensions. Because the input filter for RSVP items is initially governed by the endogenous signals, only task-relevant, category uniformity would majorly induce the TSR cost. Task-irrelevant dimension did not seem to take away endogenous control from the input filter, so we speculate that this is why the color uniformity effect is limited compared to task-relevant category uniformity.

Interestingly, the current results cast a discrepancy with the earlier studies which showed that the AB was less severe when T1 + 1 was perceptually or conceptually dissimilar to both T1 and T2 (Dux & Coltheart, 2005; Raymond et al., 1995; Shapiro et al., 1994). For example, when perceptually distinguished random dot patterns, a long-blank interval, or spatially deviated letter were used as T1 + 1, the AB was attenuated. As well as these perceptually different T1 + 1 worked, conceptually different T1 + 1 diminished the AB effects. In Dux and Coltheart study, perceptual difference of T1 + 1 was controlled by using Digitface font (e.g., "0" and "5" in Digitface font can be either interpreted as numbers "0" and "5" or alphabets "O" and "S") and their conceptual meaning was manipulated across the block. The results showed that the AB was severe when the T1 + 1 in Digitface font was regarded as the target category item. In both Di Lollo et al. (2005) and the current study, T3 was better identified when the preceding T1 + 1 item shares the category and color with T1 and T3. The current results do not give the direct and precise reason why the contradicted results were born. These might be caused by some methodological and procedural differences between these two groups of studies.

It is noteworthy that there are behavioral and neural evidences supporting the resource account in explaining the AB effects (Dell' Acqua, Jolicoeur, Luria, & Plychino, 2009; Johnston, Linden, & Shapiro, 2012; Pincham & Szucs, 2012). Especially, Dell'Acqua et al. (2009) refuted TLC account directly. In their experiment, a single or multiple numbers of targets were mixed with distractors in RSVP stream. The number of targets and lag were manipulated to form the different contexts.

According to the contextual condition, even the uniform target string condition suffered from AB effects. Also, they argued that the AB effects would be better explained by resource model rather than TLC account when the accuracy was analyzed by within-trial contingency principle. For neural evidence, Johnston et al. (2012) scanned the participants while they conducted the AB experiments. Then, they compared the functional brain images from AB experiments with ones collected from working-memory experiment. The similar fronto-parietal area were activated in both images indicating that the similar capacity limited resource involves in both paradigm. However, Di Lollo and his colleagues argued against Dell'Acqua et al. in the recent article (Olivers, Hylleman, Spalek, Kawahara, & Di Lollo, 2011). They showed that contextual effect in Dell' Acqua et al. was dissociable from attentional blink. Also, considering that activations in the frontal lobe are frequently relevant to many different types of cognitive tasks, it is still not known which account better explains the AB effects, so more studies are needed.

Multiple studies have been done to explain the AB effects in terms of the cognitive limitations. However, relatively small studies are done to understand how the cognitive mechanisms interact with or are affected by instant, bottom-up information. The current results showed not only the uniformity of pre-defined target dimension but also that of instantly established, task-irrelevant dimension modulated the AB effects. The study indicates that the attentional disruption in temporal domain is governed not only by pre-defined top-down goal but also by instantly obtained bottom-up information although the effect is limited. The finding here adds a general understanding of how interaction between the top-down goal in the task set and the bottom-up information from the stimuli affects the temporal attentional process and its limitation.

References

Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision, 10*(4), 433-436.

Chun, M. M., & Potter, M. C. (1995). A two-stage model for multiple target detection in rapid serial visual presentation. *Journal of Experimental Psychology: Human Perception and Performance, 21*(1), 109-127.

Dell'Acqua, R., Jolicoeur, P., Luria, R., & Pluchino, P. (2009). Reevaluating encoding-capacity limitations as a cause of the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *35*(2), 338-351.

Di Lollo, V., Kawahara, J., Shahab Ghorashi, S. M., & Enns, J. T. (2005). The attentional blink: resource depletion or temporary loss of control? *Psychological Research, 69*(3), 191-200.

Duncan, J. (1984). Selective attention and the organization of visual information. *Journal of Experimental Psychology: General, 113*(4), 501-517.

Dux, P. E., & Coltheart, V. (2005). The meaning of the mask matters: evidence of conceptual interference in the attentional blink. *Psychological Science, 16*(10), 775-779.

Egly, R., Driver, J., & Rafal, R. D. (1994). Shifting visual attention between objects and locations: evidence from normal and parietal lesion subjects. *Journal of Experimental Psychology: General, 123*(2), 161-177.

Johnston, S., Linden, D. E., & Shapiro K. L. (2012). Functional imaging reveals working memory and attention interact to produce the attentional blink. *Journal of Cognitive Neuroscience*, *24*(1), 28-38.

Kim, M. S., & Cave, K. R. (1999). Grouping effects on spatial attention in visual search. *Journal of General Psychology, 126*(4), 326-352.

Luck, S. J., Vogel, E. K., & Shapiro, K. L. (1996). Word meanings can be accessed but not reported during the attentional blink. *Nature, 383*(6601), 616-618.

Monsell, S. (2003). Task switching. *Trendsin Cognitive Sciences,* 7(3), 134-140.

Olivers, C. N. L., Hulleman, J., Spalek, T., Kawahara, J., & Di Lollo, V. (2011). The sparing is far from spurious: Reevaluating within-trial contigency effects in the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *37*(2), 396-408.

Pincham, H., & Szucs, D. (2012). Target cueing provides support for target-and resource- based models of the attentional blink. *PLoSONE*, 7(5), 1-13.

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: an attentional blink? *Journal of Experimental Psychology: Human Perception and Performance, 18*(3), 849-860.

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1995). Similarity determines the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance, 21*(3), 653-662.

Shapiro, K. L., Arnell, K. M., & Raymond, J. E. (1997). The attentional blink. *Trends in Cognitive Sciences, 1*(8), 291-296.

Shapiro, K. L., & Luck, S. J. (1999). The attentional blink: A front-end mechanism for fleeting memories. In V. Coltheart (Ed.), *Fleeting Memories: Cognition of Brief Visual Stimuli* (pp.95-118). Cambridge, MA: MIT Press.

Shapiro, K. L., Raymond, J. E., & Arnell, K. M. (1994). Attention to visual pattern information produces the attentional blink in rapid serial visual presentation. *Journal of Experimental Psychology: Human Perception and Performance, 20*(2), 357-371.

Ward, R., Duncan, J., & Shapiro, K. (1996). The Slow Time-Course of Visual Attention.

Cognitive Psychology, 30(1), 79-109.

Ward, R., Duncan, J., & Shapiro, K. (1997). Effects of similarity, difficulty, and nontarget presentation on the time course of visual attention. *Perception & Psychophysics, 59*(4), 593-600.

1 차원고접수 : 2012. 7. 31
수정원고접수 : 2012. 9. 13
최종게재결정 : 2012. 9. 21

한국심리학회지 : 인지 및 생물
The Korean Journal of Cognitive and Biological Psychology
2012, Vol. 24, No. 3, 281-293

과제와 무관한 색의 통일성이 순간적 주의 상실에 미치는 영향

김 장 진
연세대학교 인간행동연구소

김 민 식
연세대학교심리학과

일련의 방해자극들이 빠르게 제시되는 상황하에서 표적 자극을 탐색할 때 첫 번째 표적 자극을 정확하게 식별하는 것은 500 msec안에 나타난 뒤이은 표적 자극의 감지를 방해한다: 이를 순간적 주의 상실(attentional blink)이라 한다. Di Lollo와 동료들(2005)은 외인적으로 촉발되는 입력 필터의 일시적인 통제력 상실이 순간적 주의 상실을 설명한다고 제안했다: 그들은 일련의 표적 자극 사이에 표적 범주에 속하지 않는 자극이 있는 경우에는 순간적 주의 상실이 나타나지만, 일련의 표적자극이 모두 같은 범주의 자극으로 구성될때는 순간적 주의 상실이 사라짐을 보였다. 본 연구는 즉각적으로 확립되는, 과제와 무관한 자극의 세부 특징의 통일성이 시간적 시각 처리에 미치는 영향을 알아보았다. 과제와 관련된, 표적 자극을 정의하는 속성(범주)의 통일성과 즉각적으로 확립되는 과제 무관한 세부 특징 (색)의 통일성을 실험적으로 조작하였다. 그 결과, 과제와 연관된 범주 통일성이 없는 경우에는 과제와 무관한 색의 통일성은 순간적 주의 상실 효과를 감소시키지 못함을 발견하였다. 그러나 과제와 관련된 범주의 통일성과 과제와 무관한 색의 통일성 모두 순간적 주의 상실 효과를 감소시킴을 확인하였다.

주요어 : 순간적 주의 상실, 시간적 시각 처리, 범주 일률성, 색 일률성, 과제 무관성