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The Presence of a Weapon Shrinks the Functional Field of View†

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Summary: This study examined whether the functional field of view shrinks by the presence of a weapon or the increase of emotional arousal. In Experiment 1, participants viewed two types of pictures depicting scenes involving weapons or control objects and were asked to identify digits presented at the periphery when the pictures disappeared. The results showed that the presence of a weapon impaired identification of the peripheral digits, even when the pictures were equal with respect to emotional arousal level. In Experiment 2, participants viewed emotionally arousing pictures or neutral pictures, neither of which included weapons, and they were asked to identify digits presented at the periphery when the pictures disappeared. The results revealed that the increased emotional arousal did not impair identification of the peripheral digits. These results indicate that the functional field of view shrinks because of the presence of a weapon but not because of increased emotional arousal.

The weapon focus effect is defined as a phenomenon that when viewing an armed individual, witnesses pay most attention to the weapon and have difficulty remembering other details in the scene (e.g., Erickson, Lampinen, & Leding, 2014). In laboratory situations, when viewing a slide sequence depicting a mock crime situation including a weapon, participants tend to fixate on the weapon for a long time (Biggs, Brockmole, & Witt, 2013; Loftus, Loftus, & Messo, 1987) and to incorrectly recognize other details of the scene (e.g., Hope & Wright, 2007; Kramer, Buckhout, & Eugenio, 1990; Loftus et al., 1987; Saunders, 2009). It is also known that the presence of a weapon impairs memory accuracy for peripheral details (e.g., the face and physical features of armed individuals) but does not impair that for the weapon itself (Maass & Kohnken, 1989; Pickel, Ross, & Truelove, 2006). Reduction in reliability of witness memory is associated with a risk of an unjust verdict because witness testimony influences jurors' verdicts as strongly as physical evidence (Skolnick & Shaw, 2001). Therefore, many studies have examined the cognitive mechanisms underlying the weapon focus effect.

Two major ideas have been proposed to account for the weapon focus effect: the arousal and unusual item hypotheses. According to the arousal (or threat) hypothesis (Loftus et al., 1987; Maass & Kohnken, 1989), the weapon focus effect occurs because the threatening nature of a weapon increases witnesses' emotional arousal. When viewing a real or mock crime situation in which an armed individual threatens a victim, witnesses or participants would consider that the victim could be injured by the weapon, resulting in the increase of emotional arousal. As emotional arousal increases, witnesses are motivated to utilize central cues (i.e., a weapon) more than peripheral cues (Easterbrook, 1959). As a result, witnesses fixate on a weapon more than on peripheral details, resulting in failure to encode peripheral details. However, there has been evidence against the arousal hypothesis. For example, the presence of a weapon impaired memory accuracy for peripheral details even when the level of emotional arousal was low (Kramer et al., 1990). Furthermore, viewing a scene in which an individual behaved threateningly toward a victim did not impair memory accuracy for peripheral details (Pickel, 1998, 1999). Fawcett, Russell, Peace, and Christie (2013) calculated the effect size of threat manipulation on memory accuracy based on a meta-analysis and reported that the effect size was not statistically significant.

In contrast to the arousal hypothesis, a second idea to explain the weapon focus effect, the unusual item hypothesis, does not assume the increase of emotional arousal. In general, people have a tendency to fixate on an unusual object longer and more frequently than on predictable objects (Loftus & Mackworth, 1978). Because the weapon typically appears in an unusual context (e.g., a gun in a restaurant), witnesses tend to fixate on the weapon, resulting in difficulty encoding other peripheral details. The unusual item hypothesis has been supported by some empirical evidence (Pickel, 1998, 1999). Fawcett et al. (2013) calculated the effect size of unusualness manipulation on memory accuracy based on a meta-analysis, and reported a significantly positive effect size.

Whereas both the arousal and unusual item hypotheses assume that items are encoded efficiently in foveal viewing, recent studies suggest that peripheral viewing also plays a role in memory encoding (e.g., Huebner & Gegenfurtner, 2010). Peripheral viewing is closely related to the *functional field of view* (FFOV), defined as the area around the fixation point in which visual information is being detected and identified (Mackworth, 1965). The FFOV becomes narrower when participants fixate on a complex stimulus (Ikeda & Takeuchi, 1975) and when they are engaged in a task that requires additional attentional resources (Leibowitz & Appelle, 1969). Because a weapon can be unusual in some contexts, participants may devote their attentional resources to the weapon, resulting in a shrinkage of the FFOV, which causes failure in encoding peripheral details (Oue, Hakoda, & Onuma, 2006). In an attempt to emphasize the role of

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FFOV as a cause of the weapon focus effect, we call this idea the FFOV hypothesis.

Whereas the arousal hypothesis asserts that the weapon focus effect occurs when the level of emotional arousal increases, the FFOV hypothesis asserts that the weapon focus effect occurs without the increase of emotional arousal. The prediction from the FFOV hypothesis is obtained from the previous results in which the weapon focus effect occurred when participants' arousal level was low (Kramer et al., 1990) and in which viewing an individual behavior threatening to a victim did not cause the weapon focus effect (Pickel, 1998, 1999). However, no study has examined the effect of a weapon on participants' FFOV while controlling the level of emotional arousal. Therefore, Experiment 1 examined whether the presence of a weapon shrinks the FFOV even when the emotional arousal is equal between conditions.

Recently, some studies have provided evidence for the arousal hypothesis, by showing that participants' FFOV shrunk when viewing emotionally arousing stimuli (Nobata, Hakoda, & Ninose, 2010; Oue, Hakoda, Onuma, & Morikawa, 2001). In these studies, however, the manipulation of arousal might be confounded by the presence of weapons because some of the emotionally arousing stimuli included weapons (e.g., a gun or a knife). Therefore, in Experiment 2, to reexamine whether emotional arousal shrinks participants' FFOV, we manipulated emotional arousal by using pictures that did not include any weapon.

To measure participants' FFOV, we used a digit-identification task in which participants viewed pictures and recognized target digits. In this task, participants viewed pictures while their eye movements were recorded. Immediately after the picture had disappeared, a digit was presented at the periphery. The retinal eccentricity of peripheral digits was controlled on the basis of the participants' gaze position at the moment the picture disappeared. Hope and Wright (2007) used a similar task and stimulus but did not monitor eye movements nor manipulate the eccentricity of the target stimulus. If the FFOV becomes narrower when participants view pictures, participants would have trouble identifying peripheral digits.

EXPERIMENT 1

In Experiment 1, we examined whether the presence of a weapon shrinks participants' FFOV while controlling the emotional arousal of pictures. Participants viewed two types of picture: one included weapons, and the other included control objects. These pictures were equal with respect to the level of emotional arousal. If the presence of a weapon shrinks the FFOV, the participants would have more trouble identifying the peripheral digits immediately after they viewed the weapon pictures than after they viewed the control pictures.

Method

Participants

Twenty-three Kyushu University students (13 male, 10 female), aged 19–32 years ($M = 23.3$, $SD = 3.9$), participated and were paid 500 yen for their participation. All the participants were naïve to the purpose of the experiment. Thirteen participants were required to remove their glasses or contact lenses because these cause noises on the corneal reflex, which we measured to record participants' gaze.

Apparatus

A computer (Dell DIMENSION8300 with an Intel Pentium 4 processor 2.6 GHz) was used to control the presentation of stimuli and to collect data. Stimuli were displayed on a 17-in. LCD monitor (Dell E172FPb) whose refresh rate was 60 Hz, with a video card (NVIDIA GeForce FX 5200). A data process board (Nac Image Technology V-926) mounted on a PCI bus of the computer was used to record eye movement data from an eye tracking system through a serial cable. Stimuli were made using MATLAB (Math Works) with the Psychophysics Toolbox extensions (Brainard, 1997; Kleiner, Brainard, & Pelli, 2007; Pelli, 1997) running on Windows XP.

Eye movement data acquisition

Monocular eye movements were sampled at 60 Hz using an EMR-8 (Nac Image Technology) infrared eye tracking system. The spatial resolution of the system was a visual angle of approximately 0.1°. A camera for recording the left eye was mounted on the desk. The image data were sent to the EMR-8 controller and converted into coordinate data. The time lag between recording the eye tracking and using the data was approximately 10 ms in the experimental setting.

Stimuli

Two types of color picture were used (Figure 1): one included a weapon (e.g., a hand gun, an army knife, or a

Figure 1. Examples of weapon and control pictures. That on the left is a weapon picture, and that on the right is a control picture. The two types of pictures were nearly identical, except for the central object. Color versions of these pictures were used in Experiment 1

kitchen knife), and the other included a control object (e.g., a cell phone, a book, or a wallet). Different types of weapon are known to cause the weapon focus effect (e.g., a gun, a syringe, and a knife: Loftus et al., 1987; Maass & Kohnken, 1989; Pickel et al., 2006; Saunders, 2009). The weapons and control objects were arranged in the central area of each picture. The two types of picture were nearly identical, except for the central objects. One hundred and twenty pictures were used, half of which included a weapon while the others included a control object. Four of the 120 pictures were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005), and the others were taken by the first author. The pictures subtended a visual angle of 34° (1024 pixels) in width and 27° (768 pixels) in height. The mean width and height of the weapons in the 60 weapon pictures were visual angles of 10.08° and 9.60°, respectively.

We conducted a preliminary experiment to examine whether the presence of weapons in these pictures impaired memory accuracy for peripheral details. In the preliminary experiment, 15 participants viewed the weapon pictures, while other 15 viewed the control pictures. The presentation time of each picture was 500 ms. After viewing the pictures, the participants filled out a memory questionnaire. This questionnaire comprised 57 yes/no recognition items about peripheral details in the pictures. Of the 57 items, 21 were present items, which were presented at the periphery of the pictures, while the other 36 were absent items, which were not actually presented. We calculated d' values for the weapon and control pictures ($M = 0.91$ and 1.25, $SD = 0.39$ and 0.48, respectively). An independent two-tailed t-test revealed that the participants recognized peripheral details in the weapon pictures less accurately than in the control pictures, $t(28) = 2.15$, $p < .05$, $d = 0.78$. This indicates that the weapon focus effect occurred for the weapon pictures.

Another preliminary experiment was conducted to confirm that the weapon and control pictures were controlled with respect to emotional arousal. Ten participants viewed the weapon pictures (weapon group), and 11 participants viewed the control pictures (control group). After viewing the pictures, the participants estimated their emotional arousal levels by using the Japanese UWIST Mood Adjective Checklist (Shirasawa, Ishida, Hakoda, & Haraguchi, 1999), which is a Japanese translation of the UWIST Mood Adjective Checklist (Matthews, Jones, & Chamberlain, 1990). The Japanese UWIST Mood Adjective Checklist is composed of Tense Arousal, which represents negative emotional arousal states, and Energetic Arousal, which represents positive emotional arousal states. Because there were missing values for one participant in the control group, we excluded her data from the analysis. Mean scores for Tense Arousal were 19.1 and 17.9 in the weapon and control groups, respectively, and those for Energetic Arousal were 29.2 and 30.5, respectively. Independent two-tailed t-tests revealed that there was no significant difference between the two groups for Tense Arousal, $t(18) = 0.56$, $p = .58$, $d = 0.24$, or Energetic Arousal, $t(18) = 0.51$, $p = .62$, $d = 0.24$. These results indicate that the weapon pictures do not increase the level of emotional arousal relative to the control pictures.

Four digits were used to measure the range of the FFOV. These digits were 1, 3, 4, and 7, whose width was 0.4° and height was 0.6°. A random-dot pattern consisting of 3000 small squares with a width of 0.4° was used to mask the digits. The random-dot pattern covered the whole of the display screen.

Procedure

The participants read the experimental instructions and were informed in writing that some of the pictures might be unpleasant. After giving written informed consent, the participants sat in front of the monitor with a chin rest and were asked to help to calibrate the eye tracking system. The viewing distance between the participants and the monitor was 57.3 cm.

Figure 2 shows the sequence of the digit-identification task. In this task, the participants were asked to press the space key to present a fixation cross ('+') and were instructed to fixate on the fixation cross. After the fixation cross disappeared, a weapon or control picture was presented for 500 ms (weapon and control conditions). Durations of fixation on weapons and control objects were measured by the eye tracking system while the participants viewed the pictures. Immediately after the pictures had disappeared, a digit appeared at the periphery for 100 ms in half of the trials, but not in the other half. The location of the peripheral digit was controlled based on the participants' fixation point at the moment when the picture disappeared. The peripheral digit was located to the upper left, upper right, lower left, or lower right of the fixation point, and the retinal eccentricity of the digit was manipulated (visual angles of 1°, 3°, 6°, 9°, or 11°). After the random-dot mask was presented for 500 ms, the participants answered a question about detection, which was 'Did you notice the digit?' If they answered 'yes' to this question, an additional question about its identification was asked, which was 'Which digit was displayed?' To answer this question, the participants selected one of five alternatives ('1', '3', '4', '7', or 'I could not recognize it'). After answering this question, the participants started the next trial. The total number of trials was 120 (2 types of object × 5 levels of retinal eccentricity × presence or absence of digits × 6 repetitions). The order of the trials was randomized across blocks and participants.

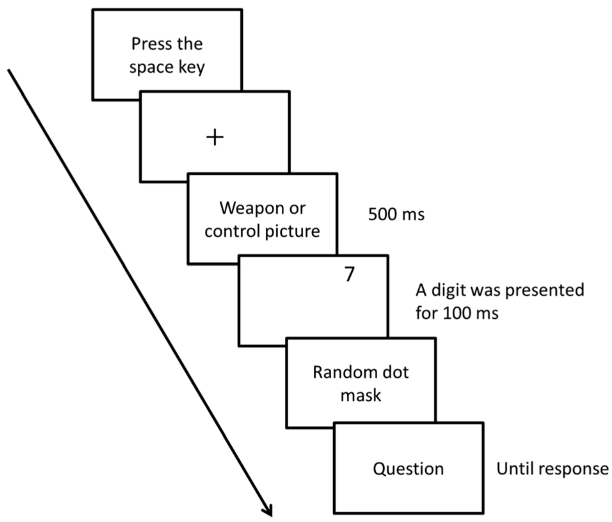

Figure 2. The sequence of the tasks used in Experiment 1

We used 30 practice trials before the experimental trials to confirm that all the participants could accurately identify the digits. In the practice trials, the following points differed from those in the experimental trials: (i) neutral pictures were presented instead of the weapon and control pictures; (ii) the retinal eccentricity of peripheral digits was fixed at a visual angle of 6°; (iii) the presentation time of the digits was 200 ms.

Design

We used two independent variables: the types of object (weapons or control objects) and the retinal eccentricity for peripheral digits (visual angles of 1°, 3°, 6°, 9°, or 11°). All the independent variables were within-participants factors.

We used the following four dependent variables: hit rate, false alarm rate, correct identification rate, and the duration of fixation. The hit rate was calculated from the proportion of 'yes' responses in digit present trials. The false alarm rate was calculated from the proportion of 'yes' responses in digit absent trials. (Because we manipulated retinal eccentricity within a block, we calculated a single value for the false alarm rate for each of the weapon and control conditions. In this setting, we could not calculate d' values for each eccentricity.) The correct identification rate was defined as the proportion of trials in which participants correctly reported the digit presented ('1', '3', '4', or '7') in the digit present trials. The duration of fixations on the weapons and control objects was calculated by the following procedure: A square of $10 \times 10°$ was superimposed on the weapons and control objects in the center of each picture because the mean width and height of the weapons in the 60 weapon pictures were visual angles of 10.08° and 9.60°. Duration of fixation was operationally defined as the duration in which the gaze of the participants' left eye stayed in the square.

Data analysis

Before analysis, we excluded data from trials (a) in which the participants moved their eyes more than two degrees during the presentation of digits (because of saccadic eye movements or eye blinks) or (b) in which the location of the digits calculated by the program was outside of the display. Consequently, we excluded 4.6% of all the data. In addition, because the correct identification rate of one participant was exceedingly low (the value collapsed across all the conditions was .13), we excluded his data from later analysis.

Results and Discussion

Hit rate

Table 1 shows the means and *SD*s of the hit rate for peripheral digits, averaged over the 22 participants. We conducted a two-way repeated measures ANOVA on the hit rates with the factors of object type (weapon or control object) and the level of eccentricity for peripheral digits (1°, 3°, 6°, 9°, or 11°). The results indicated that the main effect of levels of eccentricity was significant, $F(4, 84) = 52.9$, $p < .0001$, $\eta_p^2 = 0.72$, but neither the main effect of object type nor the interaction between object type and eccentricity was significant [$F(1, 21) = 0.01$, $p = .93$, $\eta_p^2 = 0$; $F(4, 84) = 1.64$, $p = .17$, $\eta_p^2 = 0.07$, respectively]. A *post hoc* multiple-comparison analysis using Ryan's method revealed that the hit rates at 1°, 3°, and 6° were higher than those at 9° and 11° and that the hit rate at 9° was higher than at 11°.

False alarm rate

Table 1 shows the means and *SD*s of the false alarm rate, averaged over the 22 participants. A pairwise two-tailed *t*-test was conducted on the false alarm rates and revealed that the difference between the weapon and control conditions was not significant, $t(21) = 0.18$, $p = .86$, $d = 0.03$.

Correct identification rate

Table 1 shows the means and *SD*s of the correct identification rate for peripheral digits, averaged over the 22 participants. We conducted a two-way repeated measures ANOVA on the correct identification rate with the factors of object type (weapon or control object) and the level of eccentricity for peripheral digits (1°, 3°, 6°, 9°, or 11°). The results indicated that the interaction between object type and eccentricity was significant, $F(4, 84) = 2.67$, $p < .05$, $\eta_p^2 = 0.11$. In order to examine the interaction quantitatively, for each participant, cumulative Gaussian functions were fitted to the correct identification rates for the weapon and control conditions by using the maximum-likelihood method (see Treutwein & Strasburger, 1999, for the theoretical background to the analysis). Figure 3 shows the mean correct identification rates together with the means of the best-fitting

Table 1. Means of hit rate, false alarm rate, and the correct identification rate for the peripheral digits in each object condition, and retinal eccentricity in Experiment 1

Object condition	Retinal eccentricity (degree)				
	1	3	6	9	11
Weapon condition					
Hit	0.90 (0.13)	0.94 (0.09)	0.84 (0.20)	0.77 (0.24)	0.58 (0.27)
False alarm	0.05 (0.09)				
Correct identification	0.79 (0.23)	0.82 (0.17)	0.52 (0.28)	0.29 (0.19)	0.16 (0.13)
Control condition					
Hit	0.98 (0.05)	0.92 (0.16)	0.86 (0.19)	0.78 (0.18)	0.50 (0.29)
False alarm	0.04 (0.09)				
Correct identification	0.92 (0.11)	0.78 (0.20)	0.64 (0.22)	0.33 (0.19)	0.15 (0.20)

Note: The values in the parentheses represent *SD*s of the means.

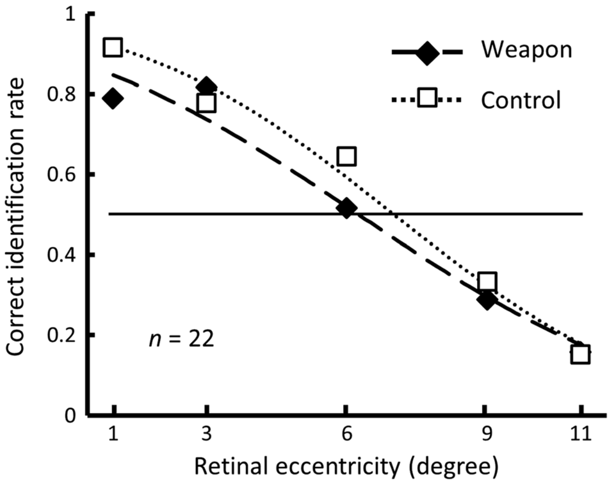

Figure 3. Mean correct identification rates and fitted cumulative Gaussian functions for the data pooled across the participants in the weapon and control conditions. Dashed and dotted lines represent fitted cumulative Gaussian functions; the horizontal solid line represents the level at which the correct identification rate is .5

lines pooled across the participants. The lines represent estimated parameters for all the correct identification rates and were qualitatively consistent with the means of the best-fitting data from each participant. To evaluate the goodness of fit of the models, we calculated McFadden's pseudo R^2 for the weapon and control conditions in each participant. Mean pseudo R^2 values were .26 and .31 in the weapon and control conditions, respectively. Hensher and Johnson (1981) noted that values of R^2 of between .2 and .4 are considered a good fit. The mean values of pseudo R^2 in the two conditions exceeded .2, indicating that these fitted models were considered to be successful.

To estimate the range of the FFOV, we calculated the mean estimated degrees of retinal eccentricity at which the correct identification rate was .5 for each participant. The means were 5.96° and 7.06° (SDs = 2.82 and 2.15) in the weapon and control conditions, respectively. A pairwise two-tailed t-test was conducted on the estimated degrees of retinal eccentricity and revealed that the retinal eccentricity in the weapon condition was significantly smaller than in the control condition, $t(21) = 2.29$, $p < .05$, $d = 0.44$. The decreased retinal eccentricity implies that the FFOV shrinks when they view a scene involving a weapon.

Duration of fixation

The mean durations of fixation were 435 and 432 ms (SDs = 39 and 42) on the weapons and control objects, respectively. A pairwise two-tailed t-test revealed that there was no significant difference in duration of fixation between the weapons and control objects, $t(21) = 0.49$, $p = .63$, $d = 0.05$.

One may argue that the participants who removed their glasses or contact lenses might not have been able to clearly view the pictures. To check this, we calculated the mean correct identification rate at the 1° condition for the participants who removed their glasses or contact lenses ($n = 12$, $M = 0.86$, $SD = 0.19$) and for the participants who did not use glasses or contact lenses ($n = 10$, $M = 0.85$, $SD = 0.1$). An independent two-tailed t-test on the correct identification rates revealed that there was no significant difference between the groups, $t(21) = 0.1$, $p = .92$, $d = 0.05$. Therefore, we consider that in the experimental settings, the participants who removed their glasses or contact lenses were able to see the pictures as clearly as the other participants.

EXPERIMENT 2

Unlike in Experiment 1, we used pictures that did not include weapons and varied their emotional arousal in Experiment 2. We measured participants' FFOV for emotionally arousing pictures and neutral pictures. If increased emotional arousal shrinks the FFOV in the absence of weapons, participants would have more trouble identifying the peripheral digits immediately after they viewed emotionally arousing pictures than after they viewed neutral pictures.

Method

The method was identical to that of Experiment 1, except for the following:

Participants

Fifteen Kyushu University students (4 male, 11 female), aged 19–34 years ($M = 22.7$, $SD = 3.4$), participated. Two of these had also participated in Experiment 1 and were not naïve as to the purpose of the experiment, while the other 13 had not participated and were naïve.

Apparatus and stimuli

The same apparatus as used in Experiment 1 was employed. Forty pictures were selected from the IAPS (Lang et al., 2005) based on the arousal and pleasantness ratings (nine-point scales). Twenty pictures that did not include weapons were identified as emotionally arousing pictures, and the other 20 pictures were identified as neutral pictures. For the emotional arousal pictures and the neutral pictures, the mean arousal ratings were 6.27 and 3.11, respectively; the mean pleasantness ratings were 2.79 and 5.92, respectively. Independent two-tailed t-tests revealed that the emotionally arousing pictures were rated as more highly arousing and more negative emotionally than the neutral pictures [$t(38) = 26.2$, $p < .0001$, $d = 4.57$; $t(38) = 15.56$, $p < .0001$, $d = 7.75$, respectively]. These rating values were consistent with those reported in a previous study that used similar images (Nobata et al., 2010; for negative emotional pictures and neutral pictures, the mean arousal ratings were 6.47 and 3.04, respectively; the mean pleasantness ratings were 2.54 and 5.25, respectively).

Procedure

The participants read the experimental instructions and were informed in writing that some of the pictures might be unpleasant. After giving written informed consent, they helped to calibrate the eye tracking system. The participants pressed the space key to present the fixation cross. After the fixation cross disappeared, an emotionally arousing picture or a neutral picture was presented for 100 ms (emotional arousal and neutral conditions). The reason that we used a

Table 2. Means of hit rate, false alarm rate, and the correct identification rate for the peripheral digits in each picture condition, and retinal eccentricity in Experiment 2

Picture condition	Retinal eccentricity (degree)				
	1	3	6	9	11
Emotional arousal condition					
Hit	0.93 (0.17)	0.96 (0.13)	0.86 (0.23)	0.61 (0.39)	0.79 (0.36)
False alarm	0.00 (0.00)				
Correct identification	0.89 (0.21)	0.89 (0.21)	0.57 (0.33)	0.29 (0.38)	0.10 (0.21)
Neutral condition					
Hit	1.00 (0.00)	0.93 (0.17)	0.79 (0.25)	0.82 (0.31)	0.54 (0.30)
False alarm	0.00 (0.00)				
Correct identification	0.96 (0.13)	0.79 (0.32)	0.46 (0.13)	0.32 (0.42)	0.07 (0.18)

Note: The values in the parentheses represent *SD*s of the means.

shorter duration than in Experiment 1 was to prevent participants from fixating salient, peripherally presented objects in the IAPS pictures used.[3] Immediately after the picture disappeared, a digit appeared for 100 ms in half of the trials, but did not appear in the other half. The location of the digit was controlled based on the same procedure as used in Experiment 1. After the random-dot mask was presented for 500 ms, the participants answered a question about detection and an additional question about identification, as in Experiment 1. For each participant, the total number of trials was 40 (2 emotional arousal levels × 5 levels of retinal eccentricity × presence or absence of digits × 2 repetitions). There were two repetitions in each condition in order to avoid affective habituation (Bradley, Lang, & Cuthbert, 1993; Dijksterhuis & Smith, 2002). Bradley et al. (1993) showed that the repeated presentation of emotional pictures reduced emotional responses such as skin conductance. The order of the trials was randomized across participants. Different images were randomly assigned to each of five eccentricity levels across participants.

Design

We used two independent variables: the types of picture (emotionally arousing or neutral pictures) and the retinal eccentricity for peripheral digits (visual angles of 1°, 3°, 6°, 9°, or 11°). All the independent variables were within-participants factors.

We used the following three dependent variables: hit rate, false alarm rate, and the correct identification rate. These dependent variables were calculated by the same procedure used in Experiment 1.

Results and Discussion

Data from one participant were excluded from the analysis because he could not correctly identify the presented digits at all (his correct identification rate was 0 under all conditions).

Table 2 shows the means and *SD*s of hit rate, false alarm rate, and the correct identification rate for peripheral digits, averaged over the 14 participants. We did not conduct an ANOVA on these data because the number of repetitions in each condition was small (two per condition). To obtain reliable estimates of the range of the FFOV, we pooled data across the participants for each condition.[4] Cumulative Gaussian functions were fitted to the correct identification rates pooled across all the participants for the emotional arousal and neutral conditions by using the maximum-likelihood method. Figure 4 shows the mean correct identification rates together with the best-fitting lines pooled across the participants. McFadden's pseudo R^2 were .32 and .34 in the emotional arousal and neutral conditions, respectively. The values of pseudo R^2 in the two conditions exceeded .2, indicating that these fitted models were considered to be good. We calculated the estimated degrees of retinal eccentricity at which the correct identification rate was .5. The estimated eccentricities were 6.70° and 6.32° (SDs = 3.78 and 3.64) in the emotional arousal and neutral conditions, respectively. To examine whether the increased emotional arousal narrowed the participants' FFOV, we conducted a nested F-test on the data pooled across all the participants (see Dosher, Han, & Lu, 2004, for the background theory for this analysis). The test revealed that the retinal eccentricity in the emotional arousal condition did not significantly differ from that in the neutral condition, $F(2, 6) = 0.39$, $p = .69$. This suggests that increased emotional arousal does not shrink participants' FFOV.

GENERAL DISCUSSION

The results from the two experiments provide some evidence for the FFOV hypothesis. In Experiment 1, the participants' FFOV became narrower when they viewed the weapon pictures in comparison with viewing the control pictures, while the pictures were equal with respect to their arousal level. This supports the idea that participants' FFOV shrinks when they view a scene including a weapon. In Experiment 2, increased emotional arousal did not narrow the FFOV. These results suggest that witnesses' FFOV shrinks because the scene includes a weapon, not because a weapon increases emotional arousal.

[3]A preliminary experiment was conducted in which participants viewed several IAPS pictures for 500 ms and were asked to identify the target digits. We found that the participants moved their eyes frequently to salient objects that appeared at the periphery. Because this could cause a problem in target digit presentation at the periphery, we presented the pictures for 100 ms, in an attempt to prevent saccades to the peripherally presented objects.

[4]In the present experiment, we used data from 140 trials to estimate the size of the FFOV per picture condition. Because the total quantity of data was not very different from the 188 trials used in a former study (Nobata et al., 2010), we regarded our estimation as reliable.

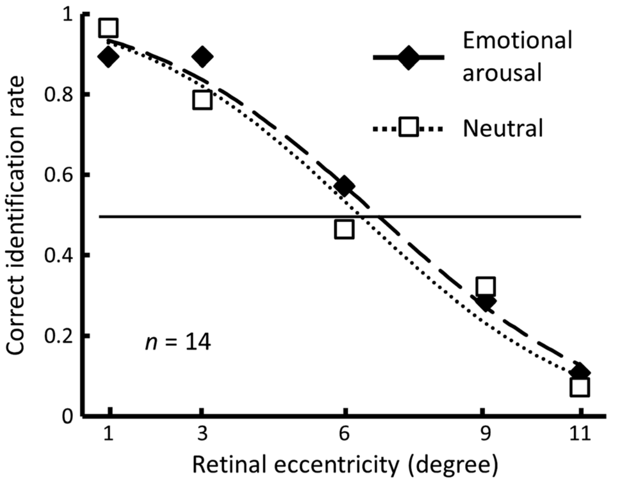

Figure 4. Mean correct identification rates and fitted cumulative Gaussian functions for the data pooled across the participants in the emotional arousal and neutral conditions. Dashed and dotted lines represent fitted cumulative Gaussian functions; the horizontal solid line represents the level at which the correct identification rate is .5

Unlike in some previous studies (Biggs et al., 2013; Loftus et al., 1987), we found in Experiment 1 that the duration of fixation on a weapon did not differ from that on a control object. This result seems to be mainly because of our experimental settings in which (a) we used a brief presentation time (500 ms) and (b) we used pictures where the weapons and the control objects appeared in an almost central position (which did not require a large saccade from the fixation) in the pictures. In such a case, the participants would fixate the weapons and control objects in a similar way but would pay more attention to the weapons than to the control objects. (If the participants viewed images that contained weapons in the periphery for several seconds, the participants would fixate weapons longer than the control objects.) If so, in Experiment 1, what caused the different identification performances between the two conditions? We speculate that when weapons are presented around the fovea, not only can there be more attention paid to the weapons but the range of spatial attention can become narrower (like a zoom-lens attention model, e.g., Eriksen & St. James, 1986, because weapons can be highly contextually unusual, as the FFOV and unusual item hypotheses predict.

Conclusion

The results from the present experiments suggest that the presence of a weapon shrinks participants' FFOV and that increased emotional arousal does not shrink the FFOV.

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