Brief Exposure to Aversive Stimuli Impairs Visual Selective Attention

Martin Paczynski, Adam M. Burton, and Amishi P. Jha

Abstract

Although it is well established that stress can disrupt complex cognitive functions, relatively little is known about how it influences visual processing, especially in terms of visual selective attention. In the current study, we used highly aversive images, taken from the International Affective Picture System, to induce acute, low-intensity stress while participants performed a visual discrimination task. Consistent with prior research, we found that anticipation of aversive stimuli increased overall amplitude of the N170, suggesting an increase in early sensory gain. More importantly, we found that stress disrupted visual selective attention. While in no-stress blocks, the amplitude of the face-sensitive N170 was higher when participants attended to faces rather than scenes in face–scene overlay images; this effect was absent under stress. This was because of an increase in N170 amplitude in the scene-attend condition under stress. We interpret these findings as suggesting that even low-intensity acute stress can impair participants’ ability to filter out task-irrelevant information. We discuss our findings in relation to how even brief exposure to low-intensity stress may adversely impact both healthy and clinical populations.

INTRODUCTION

Although stress has been found to significantly alter cognitive functions (Pabst, Schoofs, Pawlikowski, Brand, & Wolf, 2013; Grillon & Charney, 2011; Schwabe, Schächinger, de Kloet, & Oitzl, 2010; Arnsten, 2009; Susskind et al., 2008; Phelps, Ling, & Carrasco, 2006), relatively little is known about how it affects visual selective attention. Visual selective attention is the process by which early perceptual-level visual processing is selectively modulated in favor of attended versus unattended information (e.g., Mangun, 1995). In the current study, we used ERPs to examine the influence of low-intensity acute stress, akin to viewing disturbing images on television or other media, on visual selective attention, which is critical in processing information within noisy environments. Although aversive images of war, violence, and disasters are ubiquitous, their influence on basic perceptual and attentional processing has not been well investigated.

Recent work by Shackman, Maxwell, McMenamin, Greischar, and Davidson (2011) investigated the role of stress, induced by the anticipation of receiving electric shock, on early visual versus late decision-making processing in a flanker task. The authors found that stress enhanced the amplitude of the N1 but not P1 visual components, while attenuating the later P3 component associated with decision-making and target detection. On the basis of previous studies showing that the N1 is sensitive to enhancement of attended information and P1 to inhibition of unattended information (Hopfinger, Luck, & Hillyard, 2004), the authors interpreted their data as indicating that stress enhances early sensory gain without affecting visual selective attention. However, the P1, which is modulated in tasks that manipulate visual–spatial attention, is typically not modulated by the congruency manipulation of the flanker task (e.g., Purmann, Dadle, Luna-Rodriguez, & Wendt, 2011). Thus, it is unclear whether the lack of P1 modulation by stress observed by Shackman et al. (2011) truly represents a null effect on visual attention.

Here, we sought to address the question of whether acute stress affects early attentional selectivity using a modified version of the task developed by Sreenivasan, Goldstein, Lustig, Rivas, and Jha (2009). The authors found that the face-sensitive N170 was larger during attend-face blocks, when participants were asked to make gender determinations on superimposed face–scene images, compared with attend-scene blocks, in which they indicated if a scene was indoor versus outdoor. The N170 is thought to be associated with the structural encoding of complex visual stimuli (Bentin, Golland, Flevaris, Robertson, & Moscovitch, 2006). Importantly for our current question, the findings of Sreenivasan et al. (2009) and others (e.g., Mohamed, Neumann, & Schweinberger, 2009) suggest that the N170 is modulated by attention. Furthermore, because the N170 reflects feed-forward processing (Carlson & Reinke, 2010), attentional modulations of this component likely reflect the top-down influence of attention, rather than attentional reallocation after stimulus onset that could be related to decision-making (see also Sreenivasan, Sambhra, & Jha, 2011). Thus, this

University of Miami, FL
© 2015 Massachusetts Institute of Technology

Journal of Cognitive Neuroscience 27:6, pp. 1172–1179
doi:10.1162/jocn_a_00768

Downloaded from http://mitpressjournals.org/doi/pdfplus/10.1162/jocn_a_00768 by guest on 16 August 2021
paradigm is well suited for examining the influence of stress on visual selective attention.

We operationalized stress as the intermittent presentation of high arousal, negative images taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Such stimuli have previously been shown to increase physiological markers of stress/arousal, such as increased skin conductance and potentiation of the startle reflex (Sabatinelli, Bradley, & Lang, 2001). We used this novel stress manipulation to investigate if visual selective attention is influenced by exposure to more common, everyday aversive stimuli, in contrast to stressors such as threat of electric shock or ice pressor, which may be more intense than that commonly encountered within the general population on a daily basis.

If, as recently argued by Shackman et al. (2011), acute stress affects early sensory gain but not visual selective attention, an overall increase in N170 amplitude for stress compared with no-stress blocks would be predicted, independent of attention condition. On the other hand, if acute stress disrupts visual selective attention, an interaction between stress and attention would be predicted, such that attention-related modulation of the N170 component may be compromised. To investigate whether stress might also affect later attentional selection processes, we also investigated the N250. In contrast to the N170, which is thought to be sensitive to initial structural encoding of face stimuli, the N250 is thought to reflect identity-based face processing (Nasr & Esteky, 2009) and maintenance of face representations for evaluation (Böckler & Zwickel, 2013). Sreenivasan et al. (2009) found that, much like the N170, the N250 was also modulated by attention condition. Importantly for our current question, such modulation, like that of the N170, is independent of decision-making stages of selection (Gordon & Tanaka, 2011), but unlike the N170, the N250 relies on both feed-forward and feedback visual processing (Carlson & Reinke, 2010).

METHODS

Participants

Twenty-nine (16 women, 13 men, $M_{age} = 19.5$ years) right-handed undergraduate students at the University of Miami were recruited and received course credit for their participation. All participants possessed normal or corrected-to-normal vision and did not have a history of brain trauma. Informed consent was obtained from all participants in accordance with the local institutional review board. Five participants were removed from analyses: three because of recording errors and two because of excessive EEG artifacts.

Materials

Visual stimuli consisted of superimposed face–scene images containing a picture of a face and an image of an inside or outside scene. Three hundred fifty-two face–scene overlays were used in this experiment, containing an equal number of male and female faces and inside and outside scenes. Scene images were cropped to not include images of people or animals. All faces and scenes were judged by participants to be emotionally neutral (Sreenivasan et al., 2009). Faces were of low discriminability relative to scenes; 30% opaque faces were superimposed on 70% opaque scenes to produce all overlay images. Face–scene overlay images were adjusted to a mean luminance of 220 cd/m² and converted to grayscale using Adobe Photoshop. Previous studies confirmed that the gender of each face and nature of each scene could be determined by participants with 100% agreement outside of the time constraints of the experiment (Sreenivasan et al., 2009).

Stress was manipulated using images taken from the IAPS (Lang et al., 2008). For “no-stress” blocks, images selected were rated as neutrally valenced ($M = 5.01, SE = 0.54$, where $1 = \text{most negative}$, $9 = \text{most positive}$) and minimally arousing ($M = 2.36, SE = 0.26$, where $1 = \text{least arousing}$, $9 = \text{most arousing}$), and for “stress” blocks, selected images were negative ($M = 2.05, SE = 0.44$) and arousing ($M = 6.18, SE = 0.50$). Of the 24 neutral images, three depicted building components, with the remaining 21 images depicting household objects (e.g., lamp, hammer, bowl). Of the 24 negative images, two depicted aggressive animals, four inanimate objects associated with negative events (e.g., wrecked automobiles), seven depicted dead animals, and the remaining 11 images depicted human disease or mutilation (note that images were selected to not contain faces to prevent interference and/or priming of face stimuli).

Procedure

Participants were seated in a dimly lit, sound-attenuated booth, 65 cm in front of a computer monitor. The experiment consisted of a practice session followed by four experimental blocks corresponding to each combination of stress and attention: no-stress/attend-face, no-stress/attend-scene, stress/attend-face, and stress/attend-scene. Block type was counterbalanced such that, across participants, each block appeared in each of the four serial positions, with the constraint that stress conditions alternated between blocks for each participant.

Practice session consisted of 30 trials, as described below but without presentation of IAPS images. Participants who scored greater than 70% accuracy continued to the main task. Those who did not were reminded of the instructions and asked to repeat the practice session until they reached the 70% threshold.

Each trial began with a 500-msec presentation of either a blank white screen or, in 10% of trials, an IAPS image corresponding to the block type (no-stress/stress). This was followed by a face–scene overlay image presented for 500 msec. A fixation cross was then presented for 1300–1700 msec (1500 msec average). Graphic depiction
of trials is shown in Figure 1. Participants were asked to respond as quickly and accurately as possible following image presentation using button presses on a keyboard: male—“s,” female—“l,” indoor—“d,” outdoor—“k.” Each experimental block consisted of 88 trials, pseudorandomized such that no more than three trials in a row belonged to the same judgment category (e.g., female face). Stimuli were presented using E-Prime (Psychology Software Tools, Pittsburgh, PA).

As a manipulation check, before the first block and after each subsequent block, participants were asked to indicate their affect and arousal using the Self-Assessment Manikin scale (Bradley & Lang, 1994). Affect ratings ranged from 1 = highly negative to 9 = highly positive. Arousal rating ranged from 1 = not aroused at all to 9 = highly aroused.

EEG Acquisition and Analysis

The EEG was recorded using an ActiveTwo System 64-channel amplifier and data acquisition software (Biosemi, Amsterdam, the Netherlands). Ag–AgCl Active electrodes were placed upon the participant’s scalp using a Biosemi head cap, according to the modified 10–20 International System (American Clinical Neurophysiology Society, 2006). Electrodes were affixed near the lateral canthi and below the left eye to monitor eye movement and blink during the experiment. EEG data were collected at a 256-Hz sample rate using an online 0.16–100 Hz band-pass filter and average common reference.

EEG and EOG data were epoch-averaged to a period between 100 msec before and 300 msec after stimulus presentation using the ERPLAB (erplinfo.org/erplab/) Matlab package used in conjunction with EEGLAB (Delorme & Makeig, 2004). Trials containing incorrect behavioral responses or eye movement artifact greater than 100 μV were removed from analysis. Averages were bandpass-filtered between 5 and 30 Hz.

We analyzed three time windows of interest: 125–150 msec (P1), 160–190 msec (N170), and 250–300 msec (N250). Each time window was analyzed separately using a repeated-measures ANOVA. In addition to the factors Stress (no-stress, stress) and Attention (attend-face, attend-space), we also included a third factor, Time (pre, post), operationalized at the 12 sec pre-IAPS image and 12 sec post-IAPS image presentation, respectively. These time intervals were chosen as IAPS images were presented approximately once every 24 sec. This factor was included as it has previously been shown that both the anticipation and presentation of aversive images are associated with an increase in markers of stress/arousal, for example, startle reflex and skin conductance (Sabatinelli et al., 2001). Thus, we sought to determine whether effects of our stress manipulation were driven by the presentation of aversive images, their anticipation, or both. Significant interactions were followed up with pairwise comparisons.

RESULTS

Manipulation Check

Participants reported a significantly greater increase in negative affect from the beginning of stress blocks to the end (M = –1.04, SE = 1.12) compared with no-stress blocks (M = 0.21, SE = 0.93), t(23) = 3.65, p = .001, along with a significantly greater increase in arousal during stress (M = 0.12, SE = 1.44) than no-stress blocks (M = –0.80, SE = 1.43), t(23) = –2.79, p = .01.
Behavioral Results

A 2 (attention) × 2 (stress) ANOVA revealed a significant main effect of Attention on accuracy, $F(1, 23) = 10.11, p = .004$, driven by greater accuracy for attend-scene blocks ($M = 86\%$, $SE = 2.1\%$) compared with attend-face blocks ($M = 79\%$, $SE = 1.2\%$). Main effect of Stress was not significant, $F(1, 23) = 0.46, p = .83$, nor was the Attention × Stress interaction significant, $F(1, 23) = 0.88, p = .36$. For RT, there was no main effect of Attention, $F(1, 23) = 0.57, p = .81$, or Stress, $F(1, 23) = 1.66, p = .21$, nor was the Attention × Stress interaction significant, $F(1, 23) = 2.02, p = .17$. See Table 1 for accuracy and RT data for all four conditions.

Electrophysiological Results

**P1**

There was no main effect of Attention, $F(1, 23) = 0.30, p = .59$, stress, $F(1, 23) = 0.56, p = .46$, or Time, $F(1, 23) = 0.003, p = .96$. There was, however, a significant Stress × Time interaction, $F(1, 23) = 5.22, p = .03$. Pairwise comparisons indicated that the P1 evoked in stress blocks ($M = 4.6 \mu V$, $SE = 0.7 \mu V$) was marginally more positive than in no-stress blocks ($M = 4.0 \mu V$, $SE = 0.7 \mu V$), $F(1, 23) = 4.18, p = .05$, for trials in the preimage time interval, but not the postimage time interval, $F(1, 23) = 0.36, p = .56$. No other interactions reached significance, all $Fs < 2.03, ps > .17$.

**N170**

Although neither the main effect of Attention, $F(1, 23) = 2.68, p = .12$, nor Time, $F(1, 23) = 1.41, p = .25$, was significant, there was a significant main effect of Stress, $F(1, 23) = 4.29, p = .05$. This was because of the N170 being more negative under stress ($M = -4.6 \mu V$, $SE = 0.6 \mu V$), than no-stress ($M = -4.4 \mu V$, $SE = 0.5 \mu V$). This main effect was qualified by a significant Stress × Time interaction, $F(1, 23) = 15.24, p = .0007$. This was driven by stress increasing overall N170 amplitude ($M = -4.9 \mu V$, $SE = 0.6 \mu V$ vs. $M = -4.0 \mu V$, $SE = 0.6 \mu V$) for trials presented in the preimage time interval, $F(1, 23) = 11.69, p = .002$, but not in the postimage time interval, $F(1, 23) = 0.24, p = .63$ (see Figures 2 and 4A).

### Table 1. Means and Standard Errors for Behavioral and ERP Data across All Four Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Attend-face Neutral</th>
<th>Attend-scene Neutral</th>
<th>Attend-face Stress</th>
<th>Attend-scene Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>80.3 (1.2)%</td>
<td>85.6 (2.5)%</td>
<td>77.7 (1.5)%</td>
<td>86.4 (2.2)%</td>
</tr>
<tr>
<td>RT</td>
<td>742 (23) msec</td>
<td>728 (22) msec</td>
<td>712 (29) msec</td>
<td>722 (24) msec</td>
</tr>
<tr>
<td>P1</td>
<td>4.3 (0.6) $\mu V$</td>
<td>4.1 (0.6) $\mu V$</td>
<td>4.1 (0.7) $\mu V$</td>
<td>4.7 (0.6) $\mu V$</td>
</tr>
<tr>
<td>N170</td>
<td>-4.6 (0.6) $\mu V$</td>
<td>-3.5 (0.5) $\mu V$</td>
<td>-4.4 (0.5) $\mu V$</td>
<td>-4.8 (0.6) $\mu V$</td>
</tr>
<tr>
<td>N250</td>
<td>-1.2 (0.3) $\mu V$</td>
<td>-0.4 (0.2) $\mu V$</td>
<td>-1.3 (0.3) $\mu V$</td>
<td>-0.4 (0.3) $\mu V$</td>
</tr>
</tbody>
</table>

**Figure 2.** Average of ERPs evoked by face–scene overlay images at the PO8 electrode. No-stress blocks were indicated by a solid line; stress blocks were indicated by a dotted line. P1 time window: 125–150 msec. N170 time window: 160–190 msec. N250 time window: 250–300 msec. (A) ERPs evoked in the 12-sec interval before the presentation of IAPS images. (B) Distribution of the N170 effect for the no-stress and stress conditions in the preimage interval. (C) ERPs evoked in the 12-sec interval following the presentation of IAPS images. (D) Distribution of the N170 effect for the no-stress and stress conditions in the postimage interval.
There was also a significant Stress × Attention interaction, \(F(1, 23) = 9.67, p = .005\). Follow-up pairwise comparisons revealed an effect of Attention on N170 amplitude only during no-stress blocks, \(F(1, 23) = 9.36, p = .006\), but not during stress blocks, \(F(1, 23) = 1.29, p = .27\). This was because of N170 amplitude being increased by stress for the attend-scene condition, \(F(1, 23) = 12.20, p = .002\), but not the attend-face condition, \(F(1, 23) = 0.43, p = .52\). See Table 1 for mean amplitude of N170 across all four conditions (see Figures 3 and 4B).

\(N250 (250–300 \text{ msec})\)

There was a significant main effect of Attention, with the attend-face condition evoking a more negative N250 (\(M = -1.2 \mu V, SE = 0.3 \mu V\)) than the attend-space condition (\(M = -0.4 \mu V, SE = 0.2 \mu V\)), \(F(1, 23) = 19.33, p = .0002\). Neither the main effect of Stress, \(F(1, 23) = 0.02, p = .88\), nor Time, \(F(1, 23) = 0.40, p = .53\), were significant. There was also a significant Attention × Time interaction, \(F(1, 23) = 5.05, p = .04\). The effect of Attention was significant for both the preimage time interval, \(F(1, 23) = 20.22, p = .0002\), as well as the postimage time interval, \(F(1, 23) = 10.26, p = .004\); however, the magnitude of this difference was greater for the preimage interval compared with the postimage interval (\(M = -1.0 \mu V, SE = 0.2 \mu V\) and \(M = -0.6 \mu V, SE = 0.2 \mu V\), respectively), \(F(1, 23) = 5.05, p = .04\). Importantly, neither the Attention × Stress interaction nor Attention × Stress × Time interactions were significant, \(F < 1, p = .95\) and \(F < 1, p = .67\), respectively.

**DISCUSSION**

In the current study, we sought to determine whether acute, low-intensity stress, induced by intermittent presentation of aversive images, would influence early sensory processing in the human brain.
gain and/or visual selective attention. Using face–scene overlay images (see Sreenivasan et al., 2009), we were able to track covert shifts in attention as participants engaged in classification tasks for complex visual stimuli. In no-stress blocks, we found an enhanced N170 when participants attended to faces versus attending to scenes. In stress blocks, no difference in N170 amplitude was observed between attending to faces versus scenes. The absence of N170 modulation during stress was because of an increase in N170 amplitude in the attend-scene condition during stress versus no-stress blocks. We also found a main effect of stress on N170 amplitude, greater in stress than no-stress blocks, although this was apparent only for trials presented in the 12 sec before image presentation, but not in trials presented in the 12 sec following image presentation. Our findings suggest that acute stress impairs visual selective attention. Additionally, our findings suggest that increases in early sensory gain may be driven primarily by anticipation of aversive stimuli, rather than their actual presentation. Finally, our data suggest that the disruption of visual selective attention because of stress is limited to initial stages of perceptual encoding indexed by the N170 versus later stages of visual processing as the N250 component was unaffected by our stress manipulation.

One might argue that the observed lack of N170 modulation by attend condition under stress may simply reflect saturation of this component. From this perspective, the observed disruption would only be epiphenomenal, rather than representing a true degradation of attentional selectivity. This explanation, however, is unlikely. Using similar stimuli, Sreenivasan et al. (2009) found that the amplitude of the N170 for face-attend trials was higher when faces were of high discriminability versus low discriminability. Because the stimuli used in the current study were comparable to the low discriminability condition from Sreenivasan et al. (2009), it is unlikely that the face stimuli in the current study saturated the observed N170 response. Additionally, recent work by Hietanen and Nummenmaa (2011) found that images of bodies, with obscured faces, elicited a larger N170 than did faces, further suggesting that face stimuli alone, even with high discriminability, are unlikely to saturate the N170. Together, these previous results argue that our findings indicate an actual, rather than epiphenomenal, disruption of early perceptual attentional selectivity.

What might account for the disruption of visual selective attention in the current study? One possibility is that the observed impairment is specific to face stimuli, which are evolutionarily salient. Specifically, under stress it may be advantageous to rapidly detect the presence of others, whether as a potential source of help or threat, regardless of one’s current actions or goals. Thus, an evolutionary explanation is that stress may enhance the saliency of faces, making them more difficult to filter out, even when they convey information that may be task-irrelevant. This leaves open the question of whether similar impairment would be seen for a class of stimuli without evolutionary significance, such as words, which, like faces, are also processed automatically (LaBerge & Samuels, 1974). Future studies will need to explore the generalizability of the face-specific findings examined herein.

Additionally, we found that stress led to an overall increase in N170 amplitude during anticipation of aversive images. Because IAPS images appeared with regularity approximately once every 24 sec, and the stress induced increase in N170 amplitude was observed only for trials occurring within the 12 sec before aversive image presentation, but not in the 12 sec immediately after, we suggest that this effect was driven by participants’ anticipation of an upcoming aversive image, rather than as a direct consequence of aversive image presentation. Our findings are thus consistent with those of Shackman et al. (2011), who reported an increase in N1 amplitude in response to the anticipation of painful electric shocks, rather than the actual shocks, which occurred only once every several minutes. Although the N1 and N170 are functionally distinct, their similar time courses suggest that the current findings may indeed represent early sensory “gain,” similar to that described by Shackman et al. (2011).

What might account for the increase in overall N170 amplitude induced by anticipation of aversive stimuli? On the one hand, such increases may be because of the specific nature of the images used, 80% of which depicted either parts of the body or animals. Although images were selected to not contain faces, participants were unaware of this constraint. Thus, participants may have nonetheless anticipated face content in the aversive images, priming face detection processing. This would predict that aversive stimuli in which faces are visible may lead to an even greater increase in the N170 during anticipation. Alternatively, it may be the case that anticipation led to a nonspecific increase in early sensory gain, as argued by Shackman et al. (2011), throughout the extrastriate cortex, beyond areas involved in face processing. In this case, the observed increase in N170 should be independent of type of aversive stimuli anticipated.

Taken together, our findings suggest early sensory gain and visual selective attention are differently impacted by acute, low-intensity stress. The modulation of early sensory gain by anticipation suggests that this processing is subject to rapid moment by moment dynamic adjustments based on local information. On the other hand, the anticipation-independent disruption of perceptual-level attentional selection suggests that this impairment is driven by more persistent changes in information processing that may impact early sensory processing through multiple, potentially independent pathways.

One important question left open by the current study is whether the observed results are specific to aversive images. Previous studies have shown that erotic images,
such as nudes, evoke similar neural responses as aversive images presented in the current study (Weinberg & Hajcak, 2010). Additionally, anticipation of erotic images has been found to potentiate the startle response similarly to the anticipation of aversive images (Sabatinelli et al., 2001). Thus, future studies should explore if any biologically salient images lead to an increase in early sensory gain and disruption of attentional selectivity.

Overall, our findings suggest that even relatively minor stressors can disrupt the normal functioning of visual processing. Although research into the effects of stress on cognition tends to focus on stressors such as anticipation of electric shocks (e.g., Robinson, Vytl, Cornwell, & Grillon, 2013; Shackman et al., 2011) or social judgment (Lederbogen et al., 2011), the current study suggests that even less severe stressors may nonetheless lead to altered selective attention. These effects may be even more pronounced in clinical populations suffering from anxiety disorders, such as PTSD, characterized by hypervigilance in which even relatively innocuous stimuli may be perceived as aversive. Indeed, our findings point to a possible mechanism by which stress may lead to exacerbated symptoms by both reducing an individual’s ability to direct attention away from aversive stimuli as well as enhancing the stimuli’s salience at a perceptual level.

In summary, our study found that acute stress increases early sensory gain and impairs attentional selection during the processing of complex visual information. This impairment appears to be constrained to early structural perceptual processing stages. Our findings provide important insights into how stress may influence how people engage with a visually complex environment.

Acknowledgments

The authors would like to thank Dr. Shruti Baijal for her assistance with the task design. This research was supported by DOD Award W81XWH-11-2-0124.

Reprint requests should be sent to Amishi P. Jha, Mindfulness Research and Practice Initiative, University of Miami, 5665 Ponce De Leon Blvd., Coral Gables, FL 33146, or via e-mail: ajha@psy.miami.edu.

Notes

1. Image arousal and valence ratings based on IAPS norms.
2. Images used for no-stress blocks: 5130, 7000, 7004, 7006, 7010, 7020, 7026, 7010, 7020, 7026, 7031, 7041, 7060, 7090, 7110, 7140, 7175, 7185, 7187, 7217, 7490, 7491, 7705, 7900, 7950, 9360. Images used for stress blocks: 1120, 3001, 3071, 3103, 3110, 3140, 3150, 3191, 3195, 3251, 9006, 9140, 9181, 9183, 9185, 9187, 9300, 9405, 9570, 9571, 9635, 9901, 9911, 9940.

REFERENCES


