Abstract

We report a novel visual phenomenon called the *rejuvenation effect*. It causes an “old” object that has been on view for some time to acquire the properties of a suddenly-appearing new object. In each experiment, a square outline was displayed continuously on one side of fixation. The target (an asterisk) was presented briefly either inside the square or on the opposite side. On half the trials, a transient visual or auditory event preceded the target. In Experiment 1 (N=139), RTs were faster when the target appeared inside the square, but only when it was preceded by a transient event, consistent with Network Reset theory of Locus Cœruleus-Norepinephrine (LC-NE) phasic activation. Three further experiments confirmed LC-NE predictions, including the absence of rejuvenation in observers with atypical LC-NE functioning (individuals with symptoms of Autism Spectrum Disorder). These findings provide new perspectives on what causes a visual object to be perceived as new.

Stimuli that have been on view for some time ("old" stimuli) are processed very differently from suddenly-appearing stimuli ("new" stimuli; Yantis & Jonides, 1990). The onset of a new stimulus triggers a chain of processing events from sensory encoding to consolidation and memory storage. In contrast, the same stimulus does not keep on being reprocessed if it remains on view beyond a critical duration. Instead, it causes signals to be sent to higher visual centres indicating that nothing of consequence has changed (Di Lollo, 1980; von Holst, 1954). Here, we report a novel phenomenon called the "rejuvenation effect" which causes an "old" stimulus to be processed as though it were new. Rejuvenation occurs when a transient visual or auditory event causes a new processing sequence to be initiated for the old stimulus. One way in which a transient event can bring about rejuvenation is suggested by recent neurophysiological research, showing that sudden events trigger a phasic response in the Locus Cœruleus–Norepinephrine (LC-NE) neuromodulatory system (Aston-Jones & Cohen, 2005).

Located in the brainstem, the locus cœruleus is regarded as the principal source of norepinephrine in the brain (Berridge & Waterhouse, 2003). Two components of LC-NE activity have been identified: a *tonic* component, which is the baseline level of ongoing activity, and a *phasic* component, which is a transient boost in firing rate above baseline level that occurs upon the presentation of a sudden or task-relevant stimulus. Phasic LC-NE activity peaks about 100 ms after stimulus onset and endures for another 100 ms before returning to baseline (Usher et al., 1999). A general theory of LC-NE functioning, called *network reset theory*, postulates that phasic activation of the LC-NE system resets the neural networks that mediate cognitive functions (Bouret & Sara, 2005).

Central to network reset theory is the idea that specific cognitive states (e.g., focused attention) correspond to activity in distinct neural networks underlying specific responses. LC-

NE activation is said to reset the system, causing a flip between networks. Here, we test an implication of network reset theory for the processing of “old” stimuli. The novelty of our proposal is that the network reset triggered by a transient event causes a flip from a neural network signalling an unchanging square outline (i.e., a network subserving an “old” object) to a network processing the square anew from registration to memory storage (i.e., a network subserving a “new” object). As a consequence, processing should be enhanced at the location of the “new” stimulus, as is the case for any truly new stimulus (Posner & Cohen, 1984; Yantis & Jonides, 1990).

We tested this proposition with the display illustrated in Figure 1A. The fixation cross and the square outline remained on view throughout the experiment (i.e., the square was an “old” stimulus). The observer’s task was to make a speeded response to the onset of the target (an asterisk presented either inside the square or on the other side of fixation). Experiment 1 comprised two conditions. In the Transient condition, a sudden event (a 50-ms brightening of the background for the Visual group or a 50-ms sound for the Auditory group) occurred 100 ms before the target. This was intended to trigger a phasic LC-NE response with associated network reset. In the No-Transient condition, there was no sudden event.

From the perspective of network-reset theory, the sudden event should trigger a reset in the network subserving the perception of the square outline. Upon such a reset, the square should be perceived as a new stimulus, and processing at its location should be enhanced for a brief period. We thus expected RTs in the Transient condition to be faster when the asterisk was presented inside the square than when it was presented on the opposite side of fixation. No such RT differences were expected in the No-Transient condition.

The results of Experiment 1 were consistent with predictions from Network Reset theory. Experiment 1a replicated and confirmed the outcome of Experiment 1 using a fully within-subjects design. Involvement of the LC-NE system was examined in Experiment 2 by increasing the temporal gap between the transient event and the target, so that it exceeded the time course of the LC-NE phasic response. Experiment 3 provided converging evidence for the role of the LC-NE system by testing individuals who scored high on the autism spectrum scale, as those individuals have an atypical LC-NE system (Aston-Jones et al., 2007; Mehler & Purpura, 2009).

Experiment 1

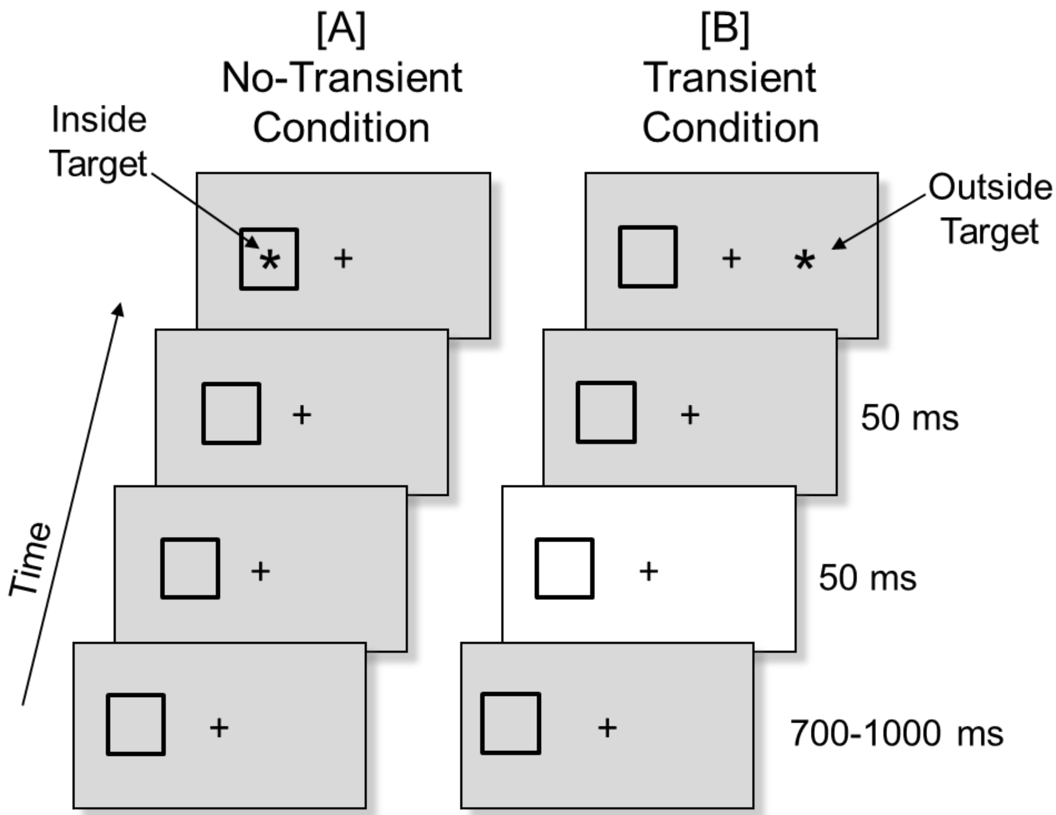

Figure 1. Display sequence for the Visual group in Experiment 1. Illustrated is a trial in which the square is presented to the left of fixation. Panel A illustrates the No-Transient condition; Panel B illustrates the Transient Condition. Panel A illustrates an Inside trial; Panel B illustrates an Outside trial.

Methods

Observers

We performed an a priori power analysis using G*Power 3.1 to estimate the appropriate number of participants in each group. Given that the rejuvenation effect is new, there were no studies that we could use for estimating effect size. Perhaps the closest paradigm is that of Posner (1980), notably, however, Posner's study involved spatial cueing whereas our study did not. In estimating an effect size, we turned to a recent review article that provides an overview and meta-analysis (Chica, Martín-Arévalo, Botta, & Lupiáñez, 2014). The average effect size was η_p^2= .27. Because of paradigmatic differences between the studies reviewed by Chica et al. and the present study, we used a conservative effect size of half of the average reported effect size (i.e., η_p^2=.12) in performing the power calculation. This yielded an estimated minimum 62 participants in each of the Visual and Auditory groups in order to detect an effect (η_p^2=.12) with 80% power (alpha set to .05).

145 undergraduate students at Griffith University and Simon Fraser University participated in the experiment for course credit. Six participants were subsequently excluded from analysis – one because the participant ended the experiment early and the rest because they responded on more than 75% of catch trials – leaving a total of 139 participants for analysis. The decision to eliminate participants who responded on the majority of catch trials was made on the assumption that participants who responded on catch trials were not performing the task properly but were simply anticipating the onset of the target. 71 participants were allocated randomly to the Visual group; 68 participants were allocated randomly to the Auditory group. Of those participants in the Visual group, 35 participants were allocated to the Transient condition and 36 to the No-Transient condition. In the Auditory group, 36 participants were allocated to the Transient condition and 32 were allocated to the No-Transient condition.

All participants were naïve as to the purpose of the experiment and reported normal or corrected-to-normal vision. Ethical approval for this experiment and for all experiments reported in this study was granted by the Griffith University Human Research Ethics Committee and the Simon Fraser University Office of Research Ethics. Participants in all experiments reported in this study provided written consent prior to participation.

Apparatus and Stimuli

All stimuli were presented on a BenQ XL2430T computer monitor running at 144 Hz. Stimulus presentation was controlled by a custom Matlab script using libraries provided by the Psyctoolbox 3 software (Brainard, 1997; Kleiner et al., 2007; Pelli, 1997). Stimuli were viewed from a distance of approximately 60 cm. The background of the display was mid-grey. Each participant completed two blocks of trials. At the beginning of each block, a black fixation cross (0.25° × 0.25°) appeared in the center of the screen and the outline of a black square (1.4° × 1.4°) was displayed 2.5° (center-to-center) to the left or to the right of fixation. The square and fixation cross remained present continuously throughout each block of trials. For half of the participants the square was displayed to the left of fixation for the first block of trials and to the right of fixation for the second block of trials. For the remaining participants order of presentation was reversed. The target consisted of a black asterisk, which appeared unpredictably but with equal probability either in the center of the square or at the corresponding location on the opposite side of fixation (see Figure 1). We refer to these as *Inside* and *Outside* conditions, respectively.

In the Transient condition, a transient event occurred 100 ms prior to the onset of the target. In the Visual group, the transient event consisted of a 50-ms change in the background color of the entire display from mid-gray to white. During this change, the fixation cross and the square continued to be displayed in black.

In the Auditory group, the background did not change color; instead, a 50-ms sound was played 100 ms prior to the onset of the target. The sound was produced by trimming the file *Energy Whip 1.wav* (obtained from https://www.freesound.org/s/49694) to 50 ms in duration. The sound was obtained from freesound.org and used under a Creative Commons License. The sound was played to both ears through over-ear headphones worn by each participant for the duration of the experiment. Sound volume was set at 25 dB above ambient level by means of a Check Mate CM-130 sound-level meter.

Procedure

Each trial began with a random interval of 700-1000 ms. In the Transient condition, this was followed by a 50-ms period during which either the entire screen was brightened (Visual group) or a sound was played (Auditory group). In the No-Transient condition, the screen remained the standard mid-gray colour for this 50-ms period and no sound was played. After a subsequent delay of 50 ms, the target was presented unpredictably but with equal probability either inside the square (Inside condition) or at the corresponding blank location on the other side of fixation (Outside condition) and remained on the screen until a response was made. The task was to press a response key as quickly as possible when the target appeared. On 10% of trials, no target was presented and participants were instructed to withhold their responses. These catch trials served to ensure that participants did not press the response key either in anticipation of the appearance of the target or in response to the transient event in the Transient condition. Each participant completed 40 trials per condition.

Results

Trials with extreme RTs (2.5 standard deviations above or below the mean) were excluded from analysis, which resulted in elimination of <1% of the trials in both the Visual and the Auditory groups. Figure 2 illustrates the mean of the median RT scores in the Inside and Outside conditions for both the Transient and the No-Transient conditions. The results of the Visual group are illustrated in Panel A; the results of the Auditory group are illustrated in Panel B.

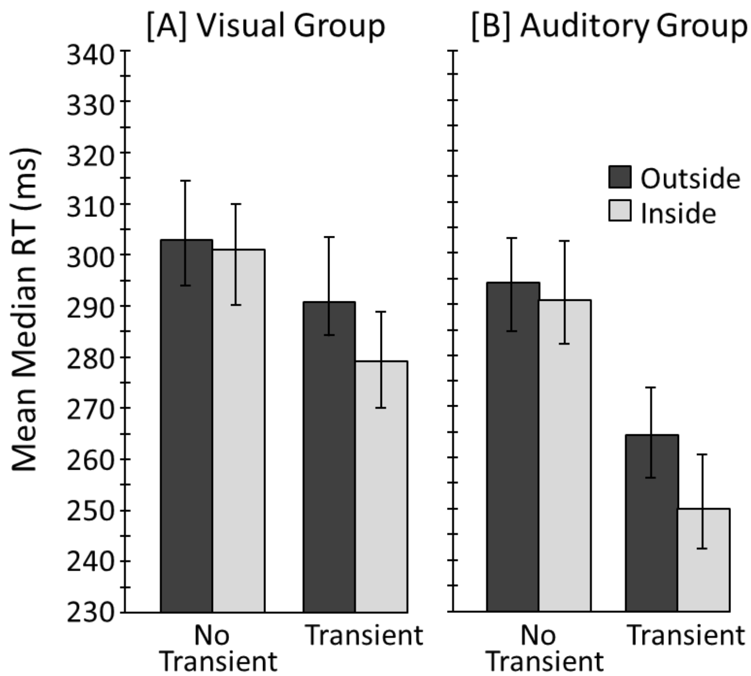

Figure 2. Results of Experiment 1. The graphs illustrate the mean of the median RTs to targets presented outside the square and inside the square. Panel A illustrates the results of the Visual Group. Panel B illustrates the results of the Auditory Group. Error bars indicate 95% confidence intervals.

The results for the Visual and Auditory groups were analyzed in two separate 2 (Target Location: Inside, Outside) × 2 (Transient Condition: Transient, No-Transient) mixed-design repeated-measures ANOVAs. Target Location was the within-subjects factor; Transient Condition was the between-groups factor.

Visual Group. The analysis revealed significant main effects of Transient Condition, $F(1,69)=4.82$, $p<.032$, $\eta_p^2=.065$, and Target Location, $F(1,69)=28.56$, $p<.001$, $\eta_p^2=.293$. Critically, the interaction between Transient Condition and Target Location was significant, $F(1,69)=9.57$, $p=.003$, $\eta_p^2=.122$. Individual t-tests revealed that RTs were significantly faster to

Inside targets than to Outside targets in the Transient condition ($t(34)=5.26$, $p<.001$) but not in the No-Transient condition ($t(35)=1.87$, $p=.07$).

Auditory Group. As with the Visual group, the data were analyzed in a 2 (Target Location: Inside, Outside) × 2 (Transient Condition: Transient, No-Transient) mixed-design repeated-measures ANOVA. The analysis revealed significant main effects of Transient Condition, $F(1,66)=30.82$, $p<.001$, $\eta_p^2=.318$, and Target Location, $F(1,66)=14.67$, $p<.001$, $\eta_p^2=.182$. Importantly, the interaction between Transient Condition and Target Location was also significant, $F(1,66)=7.37$, $p=.008$, $\eta_p^2=.100$. Individual t-tests revealed that RTs were significantly faster to Inside targets than to Outside targets in the Transient condition ($t(35)=5.60$, $p<.001$) but not in the No-Transient condition ($t(31)=.669$, $p=.508$).

Discussion

The most important finding was that RTs were faster when the target appeared inside the square than on the opposite side of the display, *but only when it was preceded by a transient event.* This novel finding is consistent with the idea that activation of LC-NE by a transient event causes a network reset (Bouret & Sara, 2005). From this perspective, the system switched networks from one that signalled an unchanging square outline to one that processed the square anew from registration to memory storage. As a consequence, processing was enhanced (faster RTs) at the square's location. We refer to this as the *rejuvenation effect*, as it denotes a process by which "old" contours acquire some of the attributes of new contours. The rejuvenation effect is defined as: (Outside RT *minus* Inside RT | Transient event) > (Outside RT *minus* Inside RT | No transient event).

Equivalence of the visual and auditory stimuli as triggers for the rejuvenation effect rules out the option that the results were simply due to changes in the low-level features of the stimuli, such as changes in contrast at the edges of the square upon the brightening of the background. Also ruled out is an account of the rejuvenation effect in terms of direction of gaze. Specifically, it could be argued that observers fixated the square instead of the central cross. This would tend to decrease RTs to targets inside the square. On this hypothesis, one would expect RTs to be faster to Inside targets not only in the Transient condition but also in the No-Transient condition, which was not the case, suggesting that observers maintained central fixation.

A second aspect of the results is worth noting. Overall, RTs were faster when the target was preceded by a transient event regardless of target location (Figures 2A and 2B, right-hand pair of bars in each panel). This is consistent with the well-documented enhancing effect of alerting, which occurs when the interval between a transient event and a target is less than about 200 ms (Spalek & Di Lollo, 2011; see also Fernandez-Duque & Posner, 1997; Jefferies & Di Lollo, 2017). Such alerting effects (Transient RTs < No-Transient RTs, averaged over Inside and Outside trials) occurred in all the present experiments when the interval between the transient event and the target was 100 ms (Experiments 1, 1a, and 3), but not when it was 400 ms (Experiment 2). However, alerting and rejuvenation were clearly independent in that alerting occurred even when rejuvenation did not.

Experiment 1a

In Experiment 1, the transient event was a between-subjects manipulation. To rule out the possibility that rejuvenation arose from strategy differences between the Transient and No-Transient groups, Transient and No-Transient trials were intermixed randomly in Experiment 1a.

Participants

Using G*Power 3.1, we performed an a priori power analysis using the interaction effect size (η_p^2=.122) from the Visual Group of Experiment 1. Based on this, it was estimated that a minimum of 29 participants would be required in order to yield a power of 80% (with an alpha level of .05) to detect a difference of comparable magnitude.

Forty-five undergraduate students at Griffith University and Simon Fraser University participated in the experiment for course credit. Two participants were excluded from analysis; one for responding on the majority of catch trials, the other for average RTs that were more than 3 standard deviations from the mean. All participants were naïve as to the purpose of the experiment and reported normal or corrected-to-normal vision.

Methods

Since the effects of visual and auditory transient events were similar in Experiment 1 – both yielded a significant rejuvenation effect – we included only a visual transient in Experiment 1a. The present experiment was identical in every way to the Visual condition of Experiment 1 except that the Transient and No-Transient conditions were presented as mixed rather than blocked.

Results

Trials with extreme RTs (2.5 standard deviations above or below the mean) were excluded from analysis. Figure 3 illustrates the mean of the median RT scores, separately for Transient and No-Transient trials. The results were analyzed in a two (Target Location: Inside, Outside) × 2 (Transient: Transient, No-Transient) repeated-measures ANOVA. The analysis revealed significant main effects of Transient, $F(1,42)=107.68$, $p<.001$, $\eta_p^2=.719$, and Target Location, $F(1,42)=8.61$, $p=.005$, $\eta_p^2=.170$. Critically, the interaction between Transient and Target Location was also significant, $F(1,42)=4.71$, $p=.036$, $\eta_p^2=.101$. Individual t-tests revealed that RTs were significantly faster to Inside targets than to Outside targets in the Transient condition ($t(42)=2.96$, $p=.005$) but not in the No-Transient condition ($t(42)=1.30$, $p=.20$).

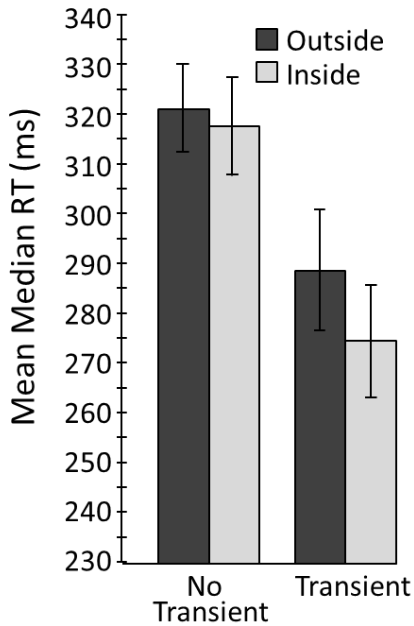

Figure 3. Results of Experiment 1a. Error bars indicate 95% confidence intervals.

Discussion

The magnitude of the rejuvenation effect [(Outside RT *minus* Inside RT | Transient event) > (Outside RT *minus* Inside RT | No transient event)] is comparable in the between-subjects design (Figure 2A) and in the within-subjects design (Figure 3), suggesting that the rejuvenation effect is unaffected by the experimental design, thus ruling out strategy as a determinant.

Experiment 2

The results of Experiments 1 and 1a were consistent with a network reset interpretation. Given that phasic LC-NE activity abates within about 200 ms (Aston-Jones & Cohen, 2005), no rejuvenation effect should be in evidence if the target follows the transient event by more than about 200 ms. This prediction was tested in Experiment 2 by increasing the interval between the transient brightening of the background and the onset of the target to 400 ms.

Observers

Using G*Power 3.1, we performed an a priori power analysis using the effect size (η_p^2=.122) from the Visual Group of Experiment 1. Based on this, it was estimated that a minimum of 29 participants in each group would be required in order to yield a power of 80% (with an alpha level of .05) to detect a difference of comparable magnitude.

Fifty-six undergraduate students at Griffith University participated in the experiment for course credit. Having shown that the blocking or mixing of trials does not affect the rejuvenation effect (Experiment 1 and 1a), we employed the between-subjects design used in Experiment 1. 28 participants were randomly allocated to the Transient group and 28 to the No Transient group.

Apparatus and Stimuli

The apparatus, stimuli, and procedures for Experiment 2 were the same as those of the Visual group in Experiment 1 with a single exception. In the Transient condition of Experiment 1, the background changed from mid-gray to white for 50 ms, 100 ms prior to the onset of the target. In Experiment 2, the background also changed from mid-gray to white for 50 ms, but the change occurred 400 ms prior to the onset of the target.

Results

Trials with extreme RTs (2.5 standard deviations above or below the mean) were excluded from analysis, leading to an elimination of 1.8% of the trials in the No-Transient condition and 1.6% of the trials in the Transient condition. Figure 4 illustrates the mean of the median RT scores in the Inside and Outside conditions separately for the Transient and the No-Transient groups. The data were analyzed in a 2 (Target Location: Inside, Outside) × 2 (Transient Group: Transient, No-Transient) mixed-design repeated-measures ANOVA.

The analysis revealed no significant effects. Neither main effect was significant [Target Location, $F(1,54)=1.25$, $p=.269$, $\eta_p^2=.0.23$, ; Transient Condition, $F<1$], nor was the interaction effect, $F<1$.

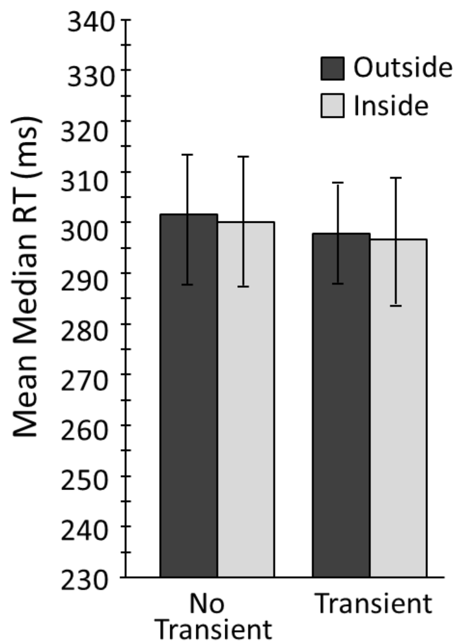

Figure 4. Results of Experiment 2. Error bars indicate 95% confidence intervals.

Discussion

The rejuvenation effect obtained in Experiments 1 and 1a was absent in Experiment 2. Comparison of the experiments lends unambiguous support to the network-reset account of LC-NE functioning. In Experiments 1 and 1a, the target arrived within the period of phasic LC-NE activation (about 200 ms) while the "old" square was being processed as "new" (rejuvenation effect), with corresponding enhancement of processing (faster RTs) at that location. In contrast, the longer SOA used in Experiment 2 (400 ms) caused the target to arrive after phasic LC-NE activation had subsided, and the contours of the square had become "old" once again. The absence of a rejuvenation effect (i.e., equal RTs on Inside and Outside trials in the Transient condition) then follows. As expected, no alerting effect (Transient RTs < No-Transient RTs, averaged over Inside and Outside trials) was in evidence in Experiment 2 because the target appeared more than 200 ms after the transient event.

Experiment 3

The results of Experiments 1, 1a, and 2 are consistent with the hypothesis that a sudden event triggers a phasic response in the LC-NE system, bringing about a network reset with attendant rejuvenation. Experiment 3 provided converging evidence by comparing two populations that are known to differ with respect to LC-NE functioning.

Individuals with Autism Spectrum Disorder (ASD) exhibit impaired functioning of the LC-NE system (Mehler & Purpura, 2009). That impairment has been attributed, at least in part, to chronic hyperphasic LC activity (Aston-Jones et al., 2007). On that account, the LC-NE system of individuals with ASD is said to be in persistent hyperphasic mode such that the phasic response triggered by a new stimulus is camouflaged by the ongoing phasic activity. Accordingly, observers with ASD should exhibit a muted phasic response to a sudden event, and should thus exhibit a reduced rejuvenation effect.

In Experiment 3, we tested typically developed individuals and assessed the degree to which they exhibited symptoms consistent with ASD as indexed by their scores on the Autism Quotient questionnaire (AQ; Baron-Cohen et al., 2001). We expected that individuals with high AQ scores would exhibit a smaller rejuvenation effect than individuals with low AQ scores.

Observers

Using G*Power 3.1, we performed an a priori power analysis using the effect size (η_p^2=.112) from the Visual Group of Experiment 1. Based on this, it was estimated that a minimum of 29 participants in each group would be required in order to yield a power of 80% (with an alpha level of .05) to detect a difference of comparable magnitude. Based on this, 169 undergraduate students at Griffith University and Simon Fraser University participated in the experiment for course credit. Nine participants were excluded from analysis – two for missing questions on the AQ questionnaire, one for not completing the experiment, one because of an error with stimulus presentation, and five for responding on the majority of catch trials. This left a total of 160 participants for analysis. All participants were naïve as to the purpose of the experiment and reported normal or corrected-to-normal vision. Participants were randomly assigned to either the Transient or the No-Transient condition.

All participants completed the AQ questionnaire (Baron-Cohen et al., 2001) and were allocated to either the High-AQ group (scores above the median; AQ score ≥ 19) or the Low-AQ group (scores below the median; AQ score < 19). There were 80 participants in the Low-AQ Group (Transient Condition: N=43; No-Transient Condition: N=37) and 80 participants in the High-AQ Group (Transient Condition: N=41; No-Transient Condition: N=39). The mean AQ score of the Low-AQ group was 14.6 in the Transient condition and 14.5 in the No-Transient condition. The mean AQ score of the High-AQ group was 23.8 in the Transient condition and 22.5 in the No-Transient condition. An AQ score of 32 or higher is considered consistent with a clinical diagnosis of Autism.

Apparatus and Stimuli

The apparatus, stimuli, and procedures for Experiment 3 were identical to those of the Visual group in Experiment 1. Each participant in Experiment 3 also completed the Autism Quotient questionnaire (Baron-Cohen et al., 2001) after completing the experiment.

The AQ is a 50-item questionnaire which assesses autistic tendencies in non-clinical groups. For each item, participants read a statement such as “I prefer to do things with others rather than on my own” and indicate whether they “strongly agree,” “slightly agree,” “slightly disagree," or "strongly disagree" with the statement. Responses were scored following the procedures outlined by Baron-Cohen et al. (2001). The AQ questionnaire is used extensively to assess the extent to which individuals exhibit traits consistent with a diagnosis of ASD (e.g., Landry & Chouinard, 2016). Possible AQ scores range from 1 to 50; the higher the AQ score, the greater the degree of autistic traits an individual exhibits.

Results

Trials with extreme RTs (2.5 standard deviations above or below the mean) were excluded from analysis, leading to an elimination of <1% of the trials in both the Low-AQ and the High-AQ groups. Figure 5 illustrates the mean of the median RT scores in the Transient and No-Transient conditions as a function of Target Location, separately for the Low- and High-AQ groups (Panels A and B, respectively).

The data were analyzed in a mixed-design 2 × 2 × 2 ANOVA. The between factors were AQ (High, Low) and Transient Condition (Transient, No-Transient). The within-subject factor was Target Location (Inside, Outside). The analysis revealed significant main effects of Target Location, $F(1,156)=27.116$, $p<.001$, $\eta_p^2=.148$, and Transient Condition, $F(1,156)=20.96$, $p<.001$, $\eta_p^2=.118$. The main effect of AQ was not significant, $F(1,156)=1.20$, $p=.276$, $\eta_p^2=.008$. There were significant two-way interactions between Target Location and AQ, $F(1,156)=9.73$, $p=.002$, $\eta_p^2=.059$, and Target Location and Transient Condition, $F(1,156)=15.52$, $p<.001$, $\eta_p^2=.090$. Critically, the three-way interaction between Target Location, AQ, and Transient Condition was significant, $F(1,156)=9.21$, $p=.003$, $\eta_p^2=.056$. For the Low-AQ group, follow-up t-tests revealed that RTs were significantly faster to Inside targets than to Outside targets in the Transient condition ($t(42)=7.21$, $p<.001$) but not in the No-Transient condition ($t(36)=.72$, $p=.477$). For the High-AQ group, individual t-tests revealed no RT difference between Outside and Inside targets in either the Transient condition ($t(40)=1.41$, $p=.166$) or in the No-Transient condition ($t(38)=.67$, $p=.507$).

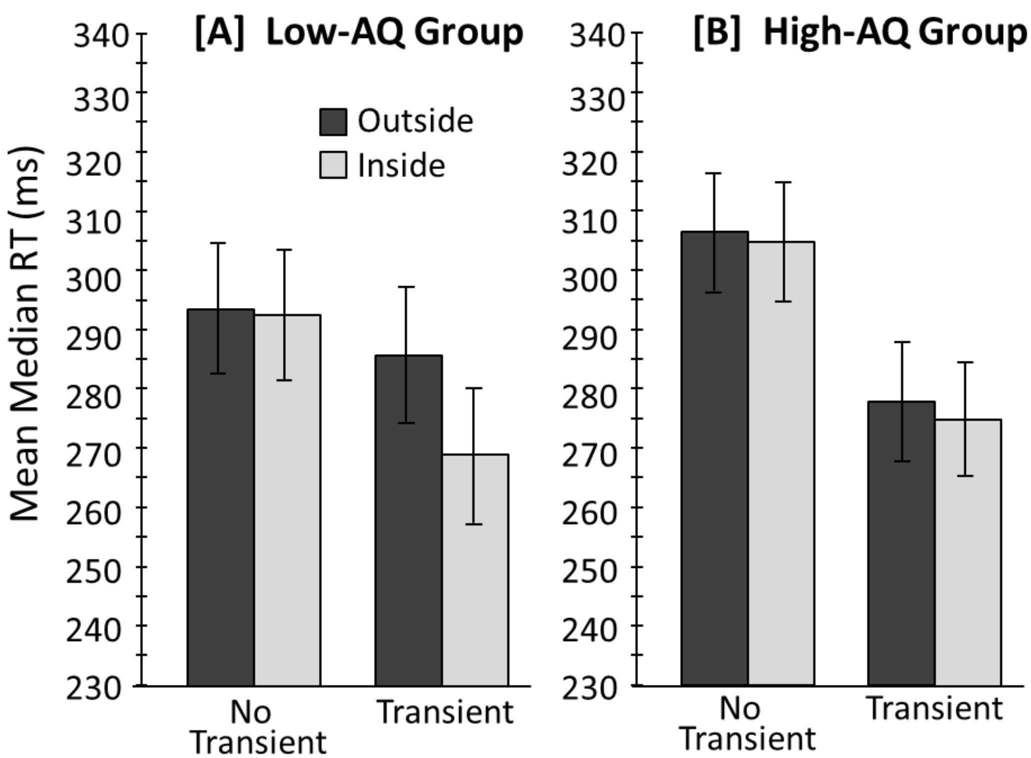

Figure 5. Results of Experiment 3. RTs were significantly faster to targets presented inside the box than to targets presented outside the box for the Low-AQ group (Panel A) but not for the High-AQ group (Panel B), in the presence of a transient event. Error bars indicate 95% confidence intervals.

Discussion

The key outcome was the significant three-way interaction, which confirmed that the only condition in which Inside RTs were significantly faster than Outside RTs occurred for the Low-AQ group in the Transient condition. In short, rejuvenation occurred only for the Low-AQ group.

This pattern of results is consistent with the idea that the LC-NE system in individuals with high AQ scores is in persistent hyperphasic mode such that the phasic response triggered by a new stimulus is camouflaged by ongoing phasic activity (Aston-Jones et al., 2007). In the case of low-AQ observers, the transient brightening of the screen triggered a distinctive phasic response which led to a rejuvenation effect. In contrast, for high-AQ observers, the phasic response triggered by the transient event was masked by the ongoing phasic activity, and the rejuvenation effect was correspondingly absent.

Conclusions

Considered collectively, the present results are consistent with Network Reset theory of LC-NE functioning (Bouret & Sara, 2005). They are also consistent with the Adaptive Gain theory of Aston-Jones and colleagues (Aston-Jones & Cohen, 2005; Aston-Jones, Rajkowski, & Cohen, 1999). Both theories propose that phasic LC-NE activation enhances flexibility in cognitive and perceptual processing.

At a broader level, our findings bear on the temporal dynamics of object perception, and on our understanding of what causes a visual object to be perceived as new. In the extant literature, an object is said to be "new" when it has a sudden onset or when one of its features or constituent parts undergoes a sudden change (Yantis & Jonides, 1990). The present work reveals an additional way in which an object can be perceived as "new". We call this process "rejuvenation", as it causes the visual system to treat an "old" object as though it were "new".

An important prospect broached by the present findings is that the network reset triggered by phasic LC-NE activity may not be limited to the rejuvenation effect, but may include truly new objects characterized by sudden onsets that trigger phasic LC-NE activity. On this option, phasic LC-NE activation would enhance processing at a given location, whether that location is denoted by a truly new object or by a rejuvenated object.

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Contribution Statement

Both authors contributed equally to all aspects of the study. Both approved the final version of the manuscript for submission.

Author Note

LNJ funded by a New Researcher Grant from the Menzies Health Institute of Queensland; VDL funded by the Natural Sciences and Engineering Research Council of Canada; LNJ and VDL funded by a Simon Fraser University and Griffith University Collaborative Travel Grant.

Research Disclosure Statement

Experiment 1:

1. We confirm that the total number of excluded observations and (b) the reasons for making these exclusions have been reported in the Method sections.
2. We confirm that all independent variables or manipulations, whether successful or failed, have been reported in the Method sections.
3. We confirm that all dependent variables or measures that were analyzed for this article's target research question have been reported in the Methods sections.

Experiment 2:

1. We confirm that the total number of excluded observations and (b) the reasons for making these exclusions have been reported in the Method sections.
2. We confirm that all independent variables or manipulations, whether successful or failed, have been reported in the Method sections.
3. We confirm that all dependent variables or measures that were analyzed for this article's target research question have been reported in the Methods sections.

Experiment 3:

1. We confirm that the total number of excluded observations and (b) the reasons for making these exclusions have been reported in the Method sections.
2. We confirm that all independent variables or manipulations, whether successful or failed, have been reported in the Method sections.
3. We confirm that all dependent variables or measures that were analyzed for this article's target research question have been reported in the Methods sections.