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Facilitation and disruption of lateralized syllable processing by unattended stimuli in the opposite visual field

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Abstract

The influence of lateralized unattended stimuli on the processing of attended stimuli in the opposite visual field can shed light on the nature of information that is transferred between hemispheres. On a cued bilateral task, participants tried to identify a syllable in the attended visual field, which elicits a left hemisphere (LH) advantage and different processing strategies by the two hemispheres. The same or a different syllable or a neutral stimulus appeared in the unattended field. Transmission of unattended syllable codes between hemispheres is symmetric, as revealed by equal interference for the two visual fields. The LH is more accurate than the RH in encoding unattended syllables, as indicated by facilitation in the left but not right visual field and a greater frequency of identifiable intrusions into the left than right field. However, asymmetric encoding strategies are different for attended and unattended syllables.

Keywords: Hemispheric asymmetry; Syllable processing; Inattentive processing; Callosal transmission

1. Introduction

In this study, we sought to determine how transcallosal codes of unattended sensory information from one hemisphere influence attentive processing by the other hemisphere. In particular, the questions we address concern the influence of unattended stimuli in one visual hemifield on the processing of attended consonant–vowel–consonant (CVC) nonsense syllables in the opposite visual field. Unattended stimuli in one field can influence attentive processing in the opposite field in two ways. First, unattended stimuli automatically capture attentional resources and deplete them from the attended field. Seitz and McKeever (1984) compared vocal reaction times for naming lateralized pictures of objects on a task that presented only unilateral stimuli and one that presented an attended stimulus (directed by a central arrow) in one field and a different unattended stimulus in the other. Reaction times (RTs), which were faster for the right visual field (RVF) than left visual field (LVF), were prolonged on the bilateral compared to unilateral task and more so for the inferior LVF than superior RVF. Similarly, Boles (1987, 1994) and Olk and Hartje (2001) observed longer RTs and a larger RVF advantage for cued bilateral than for unilateral words. These findings indicate that the irrelevant stimulus on cued bilateral tasks captures processing resources and depletes them more from attended stimuli in the inferior than the superior visual field.

Second, depending on the content of unattended stimuli, their transcallosal codes disrupt or facilitate attentive processing. Both evoked potential (Drysdale, Finlay, & Fulham, 1995; Drysdale, Fulham, & Finlay, 1998; Wijers et al., 1987) and behavioral (Bryden & Bulman-Fleming, 1994; Iocoboni & Zaidel, 1996; Lambert, Beard, & Thompson, 1988; Rosen, Curcio, MacKavey, & Hebert, 1975) studies demonstrate that irrelevant stimuli in an unattended visual hemifield are meaningfully processed and not filtered in early stages.

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For example, Drysdale and colleagues (1995, 1998) reported that evoked responses to bilateral letters, one attended and one unattended, differed depending on whether the unattended stimulus was a target or non-target letter. Similarly, response speeds to attended words on lexical decision tasks differ as function of lexical status of the unattended stimulus (Iocoboni & Zaidel, 1996; see also Bryden & Bulman-Fleming, 1994, for a description of unpublished pilot studies carried out by Patricia McMullen). Rosen et al. (1975) found that letters from the unattended visual field on a cued bilateral task intruded into the attended field. These and other similar observations suggest that the processing of an attended stimulus by the contralateral hemisphere is modified by transcallosal codes of the unattended stimulus in the ipsilateral visual field.

In the present study, we vary the nature of unattended stimuli in one visual field to determine how they influence the processing of an attended syllable in the opposite field. On each trial, a central arrow points to a vertically oriented CVC syllable in the attended LVF or RVF. In the opposite unattended field is the same syllable (*Same* distractors on *Same* trials), a different syllable (*Different* distractors on *Different* trials), or a string of three *false-font*s (*Neutral* distractors on *Neutral* trials) (see Fig. 1). Subjects attempt to identify the attended syllable. Because false-font strings engage different processing mechanisms than words or pseudowords (Posner & Raichle, 1994) and do not contain letters that can either facilitate or interfere with syllable processing, *Neutral* trials serve as a baseline in determining how

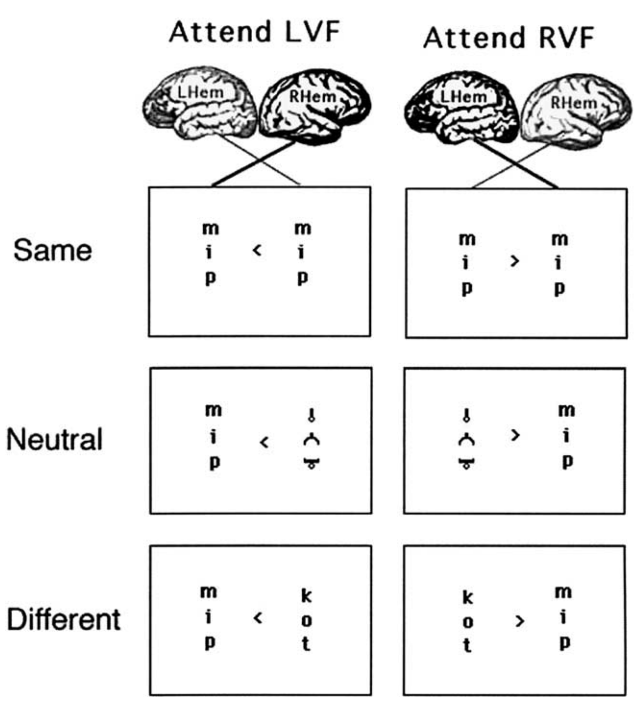

Fig. 1. Stimulus displays for *Same*, *Neutral*, and *Different* trial types.

unattended syllables on *Different* and *Same* trials affect identification of the attended syllable.

By examining error rates for individual letters at each position on the various trial types, we can determine how unattended syllables projected to one hemisphere influence the processing of attended syllables projected to the other hemisphere. Specifically, to what extent and in what ways do unattended stimuli facilitate attentive processing (performance on *Same* compared to *Neutral* trials), interfere with attentive processing (performance on *Different* compared to *Neutral* trials), and intrude from the unattended to the attended field on *Different* trials? Additionally, we can discover whether there are hemispheric asymmetries in the strategies of inattentive syllable processing, as there are for attentive processing (Levy, Heller, Banich, & Burton, 1983). Table 1 summarizes how different factors, which we discuss below, would influence facilitation, interference, and intrusions.

1.1. Interference by unattended different stimuli

There are several questions we address. One question is whether *Different* stimuli interfere with performance compared to *Neutral* stimuli. Although an unattended conflicting stimulus in one visual field interferes with performance compared to unilateral presentations (Boles, 1987, 1994; Seitz & McKeever, 1984), this might arise solely from a capture of processing resources by the distractor (Model 1). If attentional factors alone explain the decline in performance observed on cued bilateral compared to unilateral tasks, then *Neutral* or *Different* distractors would equally deplete attention from the attended syllable, in which case performance on *Neutral* and *Different* trials would be the same. Alternatively, interference might additionally reflect a disruption in processing the attended stimulus by conflicting transcallosal codes from the distractor (Model 2). If the poorer performance on cued bilateral than unilateral tasks is partly due to the conflict between an attended contralateral stimulus and transcallosal codes of an unattended ipsilateral stimulus, *Different* distractors will interfere with performance compared to *Neutral* distractors. Findings that verbal stimuli in an unattended hemifield influence responses to stimuli in the opposite attended field (Drysdale et al., 1995; Drysdale et al., 1998; Iocoboni & Zaidel, 1996; Lambert et al., 1988; Mohr, Pulvermueller, & Zaidel, 1994; Rosen et al., 1975; Wijers et al., 1987) indicate that transcallosal codes of the unattended stimulus are transmitted to the attentive hemisphere. We therefore posit that a distractor that conflicts with an attended syllable (*Different* trials) will interfere with performance compared to a neutral distractor (*Neutral* trials).

If *Different* distractors interfere with performance, is the interference equal for the two fields or greater for the LVF, which is inferior in syllable processing (Levy

Table 1
Hypothetical effects of unattended stimuli in one visual field on attentive processing of syllables in the opposite field

Model	Interference (*Different* minus *Neutral*)	Facilitation (*Neutral* minus *Same*)	Intrusions (on *Different* trials)
Model 1 The only effect of unattended distractors in one hemifield is to deplete resources from the attended hemifield	No (unattended *Neutral* and *Different* distractors deplete resources equally from the attended field)	No (*Neutral* and *Same* distractors deplete resources equally from the attended field)	No
Model 2 Transcallosal codes of unattended stimuli influence attentive processing	Yes	Yes	Yes
Model 2A Transcallosal verbal codes of unattended stimuli are transmitted from each hemisphere to the other, but are more accurate from the left hemisphere (LH) to the right (RH) than vice versa	Symmetric (the accuracy of transcallosal codes of *Different* distractors is irrelevant to interference)	More for the RH than LH. (facilitation is highly dependent on the accuracy of transcallosal codes of *Same* distractors)	In both fields and more into the LVF (identifiable intrusions are dependent on the accuracy of transcallosal codes of *Different* distractors)
Model 2B The LH asymmetrically inhibits the RH on verbal tasks. In consequence, unattended stimuli influence attentive LVF processing, but not attentive RVF processing.	Only for RH	Only for RH	Only into the LVF
Model 2A + Q Model 2A + Qualitative error patterns are the same for inattentive as attentive processing	Symmetric overall, but more last-letter interference in RH than LH	More for RH than LH and selectively so for the last letter	More last-letter intrusions into RH than LH and vice-versa for first letters
Model 2B + Q Model 2B + Qualitative error patterns for the LH are the same for inattentive as attentive processing	Only for RH and the last letter	Only for RH and mainly the last letter	Only into RH and mainly the last letter

et al., 1983)? We first consider attentional factors (Model 1). The greater decline in performance for the inferior LVF than superior RVF on cued bilateral compared to unilateral verbal tasks (Boles, 1987, 1994; Olk & Hartje, 2001; Seitz & McKeever, 1984) implies that RVF distractors on our task would capture more attention and deplete more from the opposite field than would LVF distracters. Also, findings that the left hemisphere (LH) restricts attention to the contralateral field whereas the right hemisphere (RH) distributes attention bilaterally (see Levy, Wagner, & Luh, 1990; Posner & Raichle, 1994) suggest that RVF distractors capture more attention from the ipsilateral RH than do LVF distractors from the ipsilateral LH. However, since distractors automatically capture attention prior to their discrimination, *Different* and *Neutral* distractors would be expected to capture equal amounts of attention. Thus, attentional factors would not produce asymmetric interference on *Different* relative to *Neutral* trials.

A RVF advantage for inattentive syllable processing (Model 2A), similar to that for attentive processing (Hellige, Taylor, & Eng, 1989; Levy et al., 1983; Luh & Levy, 1995), would not generate an asymmetry of interference. Whether transcallosal codes of unattended *Different* syllables are correct or wrong, they would conflict equally with attended syllables.

There are other factors, however, that might produce greater interference in the LVF than the RVF. Some researchers suggest when one hemisphere surpasses the other for a given cognitive function, the superior hemisphere precludes interference from the inferior hemisphere by inhibiting its activity or blocking its input (Model 2B; for review of relevant findings, see Chiarello & Maxfield, 1996). According to this model, unattended distractors in the LVF would have little or no influence on processing attended syllables in the RVF, in which case, only LVF performance would be poorer on *Different* than *Neutral* trials.

1.2. Facilitation by unattended same distractors

Do *Same* distractors facilitate performance relative to *Neutral* distractors, and is facilitation greater for the inferior LVF than the superior RVF? We note first that since *Same* and *Neutral* distractors should capture equal amounts of attention, attentional factors would not generate facilitation on *Same* relative to *Neutral* trials (Model 1). However, in contrast to the interference by *Different* distractors, facilitation by *Same* distractors depends on the accuracy with which they are encoded (Model 2A). Inaccurate transcallosal codes of *Same* distractors are not compatible with attended syllables and would not facilitate performance. If there is a RVF advantage for inattentive syllable encoding, then transcallosal codes of *Same* distractors would be more accurate from the LH to RH than vice versa and facilitation on *Same* trials would be greater for the LVF than RVF. If the attentive LH (RVF trials) inhibits or blocks input from the inattentive RH (Model 2B), this would also produce greater facilitation on LVF than RVF trials.

1.3. Intrusions of information from different distractors into the attended field

If there is a RVF advantage in the inattentive processing of syllables, the proportion of errors on *Different* trials that could be classified as intrusions from the opposite field would be higher into the LVF than RVF. An intrusion error can be recognized only if letters of the *Different* distractor are accurately encoded. Although codes of *Different* distractors may intrude just as often into the attended RVF as the attended LVF, they could not be identified as intrusions if the codes are incorrect. Therefore, the greater the RVF advantage in processing unattended syllables, the greater the asymmetry of *recognizable* intrusion errors relative to total errors on *Different* trials (greater into the LVF).

1.4. Patterns of errors

Other questions pertain to the patterns of errors on *Same*, *Neutral*, and *Different* trials. Attentive processing of lateralized vertical CVCs yields differing error patterns for the LVF and RVF (Hellige et al., 1989; Levy et al., 1983; Luh & Levy, 1995). Given that verbal reports of syllables or letters presented to either hemisphere are mediated by the speaking LH, the asymmetry in error patterns indicates that transcallosal codes of LVF syllables reflect the RH's specialized processing. Analyses of syllable error types (Hellige et al., 1989; Levy et al., 1983; Luh & Levy, 1995) and individual letter positions in vertically aligned stimuli (Rosen et al., 1975) show that the error rate from first to last letters rises much more steeply in the LVF than RVF, which reflects a LVF advantage for first letters and a RVF advantage for last letters. Because the RH has no capacity to derive phonetic images or speech codes, it is compelled to process syllables letter-by-letter from first to last, which results in the steep error function. The LH applies a dual-encoding process in which the whole syllable, as well as individual letters, are encoded, which flattens the error function (see Levy et al., 1983, for discussion).

If the same asymmetric error patterns pertain to inattentively encoded syllables, then facilitation on *Same* trials for the LVF would reflect a selective reduction in errors for the last letter by accurate transcallosal codes from the LH and a decrease in the asymmetry of error patterns compared to *Neutral* trials. Since error rates for first letters are low in both fields and close to zero for the LVF, ceiling effects may preclude facilitation for first letters.

As discussed previously, the accuracy with which *Different* distractors are encoded is irrelevant to their conflict with attended syllables. Although the encoding strategy applied to *Different* distractors cannot be manifested in patterns of interference, it can be manifested in patterns of intrusions. The more accurate is inattentive encoding of *Different* distractors, the greater the possibility of identifying intrusions, since misencodings would not be recognized as intrusions. Therefore, if there is a RVF advantage in inattentive processing of last letters, there would be more *recognizable* intrusions of the last letter from the unattended RVF into the attended LVF than vice versa. Although attentive processing favors the LVF for first letters, error rates are low for both fields and the asymmetry between fields is small. Nonetheless, it is possible that a LVF advantage for inattentive processing of first letters could produce more recognizable intrusions of the first letter into the RVF from LVF than vice versa.

2. Methods

2.1. Subjects

Nineteen (19) female and 18 male subjects were recruited through campus notices and paid for their participation. Subjects were university students (33 subjects) or adult residents of the university community (4 subjects). All were right-handed as assessed by a 9-item questionnaire, were native speakers of English, and had normal or corrected-to-normal near and far visual acuity and stereopsis, as assessed by the Titmus Vision Tester.

2.2. Apparatus and stimuli

Stimuli (black on a white background) were presented on a 15 in. Apple monitor under control of a Macintosh Performa 6214 CD running Superlab and viewed at a distance of 50 cm, which was fixed by a chin rest and forehead restraint. The fixation field contained a small central square (4 mm or 0.46° on a side) in which a dot appeared shortly before stimulus presentation. Each stimulus field (see Fig. 1) consisted of an arrowhead (<or>, 3 mm or 0.34° in horizonal extent) centered between two vertical 3-element stimulus arrays (1.5 cm or 1.7° in height), which were 0.75 cm (0.86°) to the left and right of the arrowhead.[3]

[3] Syllables were arranged vertically to preclude possible effects of reading habits in attentional scanning of horizonal syllables.

The array to which the arrow pointed was a consonant–vowel–consonant (CVC) syllable. On the opposite side, which subjects were to ignore, was the identical syllable (*Same* trial type), a CVC syllable that differed in all letters (*Different* trial type), or a string of three *false-font*s (*Neutral* trial type) constructed from simple elements. Syllables were in lowercase, boldface, 12-point Geneva font. A post-stimulus masking field presented two ovals of letter fragments, which masked lateral stimuli but not the central arrow.

We constructed 48 different test syllables using all vowels and 8 consonants (B, D, F, G, K, M, P, and T) and 48 different false-font strings by mapping each of 13 *false-font*s to one of the 5 vowels or 8 consonants (Fig. 2). Initial and ending consonants of a CVC were always different and each consonant appeared equally often in the first or last position. Each of the 48 test syllables appeared on the attended left side (toward which the arrow pointed) in three stimuli (*Same*, *Different*, and *Neutral* trial types) and on the attended right side in three, for a total of 288 test stimuli. The unattended side of test stimuli contained each of the 48 syllables equally often (in *Same* and *Different* trial types) and each of the 48 false-font strings equally often (in *Neutral* trial types). For practice trials, syllables constructed from different consonants (F, L, M, R, S, and V) and a subset of the false-font strings were used to make 24 different practice stimuli (8 each of *Same*, *Different*, and *Neutral* trial types).

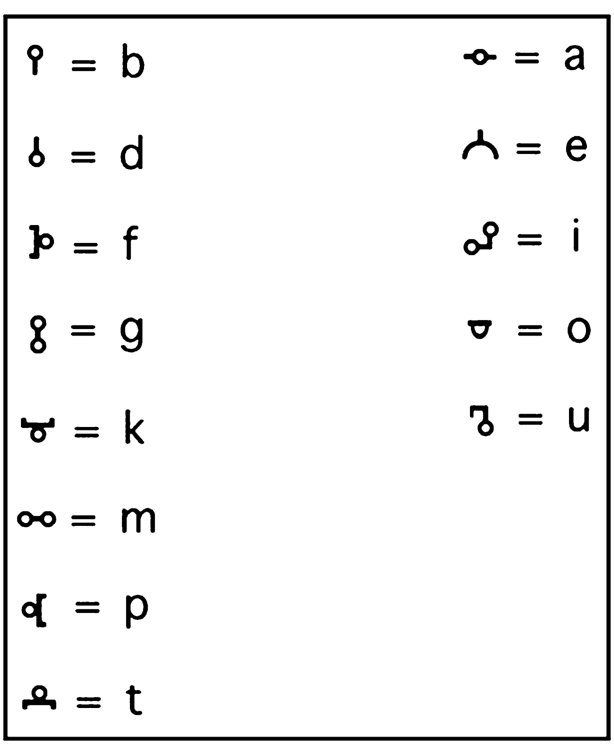

Fig. 2. Pseudofonts and their mappings to letters used to form CVCs.

2.3. Procedure

Six (6) practice stimuli were first presented as a warmup at 195 ms, then repeated among a practice block of 24 trials (each with a different stimulus). Subjects were directed to name the syllable toward which the arrow pointed and then to specify the arrow direction. Following the practice block, each subject received 288 experimental trials in 3 blocks of 96 (32 of *Same*, *Different*, and *Neutral* trial types, half of each with the arrow pointing left and half with the arrow pointing right). If the arrow direction was wrongly specified on a trial (1.9% of trials), the data from that trial were omitted from analyses. The fixation warning dot appeared in the central square 1 s prior to the stimulus field. At offset of the stimulus field, there was a 20 ms delay prior to appearance of the masking field for 200 ms.

Exposure durations for the stimulus field were set individually for each subject and changed between test blocks in an attempt to maintain overall accuracy at about 50%. The exposure duration for the first test block was determined by performance on the practice block of 24 trials. Exposure durations after every 4 practice trials were reduced by 30 ms, with initial exposure set at 195 ms and final exposure at 45 ms. Each of the 6 practice exposures was divided into the percentage correct at that exposure. The 6 results were averaged to provide an index, I_p, of the amount of information correctly processed per ms on the practice block. Where $K = 55$, the exposure duration for the first test block was specified by $E_1 = K/I_p$. Although we aimed for 50% overall accuracy, pilot studies show that if K is set as low as 50, average performance is less than 50%. The exposure durations for the second and third test blocks were specified, respectively, by

$$E_2 = \frac{K}{I_1} = \frac{KE_1}{C_1} \quad \text{and} \quad E_3 = \frac{K}{I_2} = \frac{KE_2}{C_2},$$

where C_1 and C_2 are percentages correct for the first and second test blocks. The mean percentage correct was 47.2% ($SD = 11.7\%$).

3. Results

We calculated the frequencies of errors for individual letters in the first (P1), second (P2), and third (P3) positions, which specifies the effect of letter position on accuracy more precisely than do syllable error types (Levy et al., 1983). The error rate for individual letters was the dependant variable in an ANOVA in which Letter Position (P1, P2, and P3), Visual Field and Trial Type (*Same*, *Different*, and *Neutral*) were repeated measures and Sex a between-subject factor.

The effects of Visual Field, Trial Type, Letter Position (P1, P2, and P3), and their interactions (Figs. 3 and 4)

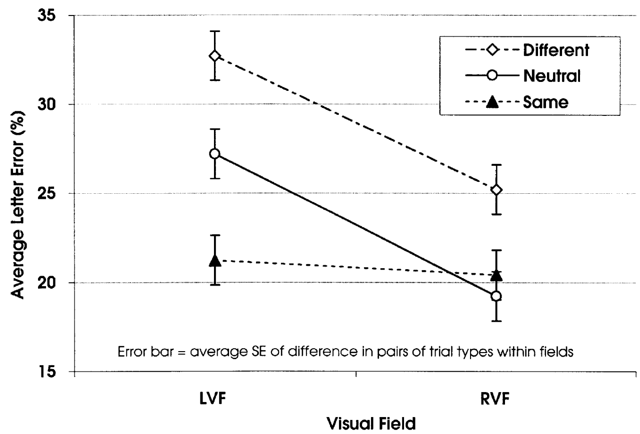

Fig. 3. Interaction of Visual Field with Trial type.

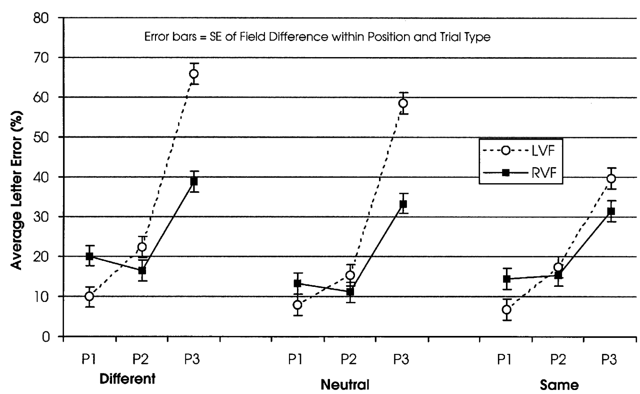

Fig. 4. The interaction of Visual Field, Trial Type, and Letter Position.

are all reliable ($p < .001$). The main effect of Position reveals increasing errors from P1 (12.1%) to P2 (16.3%) (P1 vs. P2: $p = .002$) to P3 (44.6%) (P2 vs. P3: $p < .0001$). The interaction between Letter Position and Field reflects a steeper increase in errors from P1 to P2 to P3 for the LVF–RH than RVF–LH. Planned comparisons show greater accuracy for P1 in the LVF–RH than RVF–LH ($p < .0005$) and greater accuracy for P3 in the RVF–LH than LVF–RH ($p < .0001$).

The Field by Trial Type interaction (Fig. 3) reflects interference on *Different* relative to *Neutral* trials in both the RVF–LH ($p = .008$) and LVF–RH ($p < .0001$), but facilitation on *Same* relative to *Neutral* trials in the LVF–RH ($p < .0001$) and not RVF–LH ($p = .26$).

The three-way interaction of Field, Trial Type, and Letter Position (Fig. 4) reflects the following relations. The Field by Position interaction is highly significant for all trial types (*Same* trials: $p < .0001$; *Neutral* trials: $p < .0001$; *Different* trials: $p < .0001$), which is due to better performance for P1 in the LVF–RH and better performance for P3 in the RVF–LH. However, this asymmetry of error patterns is greater on *Different* than *Neutral* trials ($p = .013$) and greater on *Neutral* than *Same* trials ($p < .0001$). In other words, the difference between visual fields in error patterns is greatest on *Different* trials and least on *Same* trials.

The influence of Trial Type on the asymmetry between fields (Field by Trial Type interaction) is restricted to P3 ($p < .0001$). For P3, there is facilitation on *Same* trials in the LVF–RH ($p < .0001$) but not RVF–LH ($p = .22$) and symmetric ($p = .40$) interference on *Different* trials in the LVF ($p < .0001$) and RVF ($p = .013$). There is no influence of Trial Type on the asymmetry of P1 ($p = .13$) or P2 ($p = .33$). For P1 and P2, there is symmetric interference on *Different* trials and no facilitation on *Same* trials.

A higher error rate for women than men on *Different* trials ($p = .048$), but no sex difference on *Same* ($p = .78$) or *Neutral* ($p = .99$) trials, led to an interaction between Sex and Trial Type ($p = .015$). The only other sex difference appeared on *Neutral* trials, where the increase in errors from the first to third letter was steeper for women than men ($p = .042$ for the Sex by Position interaction). The reliability of these effects of sex can only be determined by future research.

3.1. Error analysis on different trials

The foregoing analyses show equal interference for the LVF and RVF on *Different* trials and facilitation on *Same* trials only for the LVF. These observations are predicted by a RVF advantage for inattentive processing of syllables (Model 2A), but are inconsistent with an inhibition of the RH by the LH (Model 2B), which would prevent interference with RVF performance on *Different* compared to *Neutral* trials. As discussed, better inattentive encoding by the LH than RH would also be manifested by asymmetric intrusion errors on *Different* trials. In particular, a higher proportion of errors could be *identified* as intrusions on LVF than on RVF trials. Although codes of unattended *Different* syllables may intrude just as often into the attended RVF as the attended LVF, they could not be identified as intrusions if the codes are incorrect. Thus, a RVF advantage in inattentive processing predicts a higher frequency of *identifiable* intrusion errors relative to other errors into the LVF than RVF.

Errors on *Different* trials were classified into three types: Reports of letters not included in the set of letters presented at a given position (*Non-Set* errors) and two types of *Set* errors, which comprised *Intrusions* and *Set Non-intrusions*. *Set* errors for P1 and P3 are inaccurate reports of one of the eight consonants presented at these positions and for P2 are one of the five vowels presented at this position. An *Intrusion* is a report of a letter presented at the same position in the unattended field on a given trial, whereas a *Set Non-intrusion* is an incorrect letter from the set but not an intrusion. Because all five vowels were included in the task, errors at P2 were *Set* errors (either *Intrusions* or *Non-Intrusions*) unless the subject reported a consonant (which occurred on less than 1% of the trials).

3.2. Set errors relative to total errors

We first performed an ANOVA on the ratio of *Set* errors (*Intrusions* + *Non-Intrusions*) to total errors for P1 and P3 to determine whether the proportion of *Set* errors differs in the two visual fields. Sex was a between-subjects factor and Field and Position (P1, P3) were within-subject factors. As noted, *Non-Set* errors on P2 were rare (less than 1% of trials) and therefore the analysis was restricted to P1 and P3. One subject made no errors on P1 and was therefore excluded from this analysis. The only significant finding was a main effect of Position, which reflected a larger proportion of *Set* errors for P1 (82.4% of total errors) than P3 (72.3% of total errors) ($p < .005$). There was no main effect of Field nor interaction between Field and Position. Thus, the proportion of *Set* errors out of total errors did not differ between fields. The larger proportion of *Set* errors for P1 than P3 probably reflects superior learning of the P1 letters, since accuracy was higher for this position than for P3. Participants were not informed that the same set of eight letters was used for P1 and P3.

3.3. Intrusions relative to total set errors

We then restricted attention to *Set* errors to determine whether there were field asymmetries in the rate of *Intrusions* (I) compared to *Non-Intrusions* (NI) and whether the intrusion rate exceeded chance. Since there are 8 letters in the set for P1 and P3, and one is correct, there is a 1/7 a priori probability of an intrusion when an incorrect letter from the set is randomly reported. The a priori probability of an intrusion for P2 is 1/4 since there are 5 letters in the set. Thus, the observed frequency of intrusion errors includes not only the frequency of true intrusions but also 1/7 (for P1 and P3) or 1/4 (for P2) of random guesses from the set. When corrected for guessing, we obtain

$$I_{\text{corrected}} = I_{\text{observed}} - \frac{(I_{\text{observed}} + \text{NI}_{\text{observed}})}{M},$$

where M is 7 for P1 or P3 and is 4 for P2. Corrected scores were used in all analyses. At each position for both visual fields, the percentage of *Intrusions* out of total *Set* errors was far above chance ($p < .0001$ in all cases).

We performed an ANOVA on the ratio of corrected *Intrusion* errors to total *Set* errors (i.e., *Intrusions* + *Non-Intrusions*), with Sex as a between-subjects factor and Position and Field as within-subjects factors. Five subjects were excluded from the analysis because at least one of their Position by Field cells had no *Set* errors. Results are shown in Fig. 5. A main effect of Position ($p < .001$) reflected a higher percentage of *Intrusions* for vowels at P2 (55.7%) than consonants at P1 (41.2%) or P3 (37.4%). The percentage of *Intrusions* out of total *Set* errors was larger in the LVF (49.2%) than the RVF (40.2%) ($p < .01$). Although Field did not interact with Position ($p = .15$), planned comparisons showed that the ratio of *Intrusions* to total *Set* errors was significantly greater in the LVF than RVF for P1 ($p = .0021$) and P3 ($p < .0001$) but not for P2 ($p = .92$). We note that the percentage of *Intrusions* out of total errors (*Set* and *Non-Set*) was also greater for the LVF (26.7%) than RVF (18.5) ($p = .0025$).

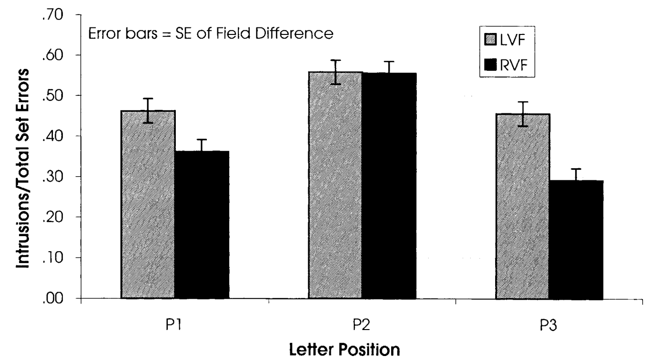

Fig. 5. The ratio of intrusion errors to total set errors as a function of Visual Field and Letter Position.

4. Discussion

We found that the content of unattended stimuli in one visual field influences attentive processing of syllables in the other, which is consistent with evoked potential (Drysdale et al., 1995; Drysdale et al., 1998; Wijers et al., 1987) and earlier behavioral (Iocoboni & Zaidel, 1996; Lambert et al., 1988; Rosen et al., 1975) studies. Although unattended stimuli in one field deplete processing resources compared to unilateral tasks and more for the inferior LVF than RVF on verbal tasks (Boles, 1987, 1994; Olk & Hartje, 2001; Seitz & McKeever, 1984), such attentional factors were equated in the present investigation across all trial types. If capturing of attentional resources were the only effect of lateralized unattended stimuli on attentive processing, then performance on our task would be unaffected by the content of unattended stimuli (see Model 1, Table 1), in conflict with observation.

The inclusion of *Neutral* distractors (false-font strings) allowed us to determine the extent to which unattended syllables that were the same as or different from attended syllables facilitated or interfered with attentive processing relative to the neutral condition (*Neutral* distractors). *Different* distractors interfere with attentive processing to equal degrees in the LVF and RVF. The symmetry of interference disconfirms a model in which the LH inhibits or blocks the input from the RH on verbal tasks (see Model 2B, Table 1) and establishes that interhemispheric communication of transcallosal codes of unattended syllables is as efficient and effective from the RH to LH as vice versa (Model 2A). Interference is present at each letter position (P1, P2, and P3) and for no position is there a reliable asymmetry in interference.

The degree of interference in each field is independent of the accuracy with which unattended syllables are encoded since both accurate and inaccurate encodings of *Different* distractors conflict with the attended syllable and disrupt performance. However, facilitative effects of *Same* distractors on attentive processing are highly dependent on the accuracy with which they are encoded. If letters of a *Same* distractor are misencoded, they conflict with the attended syllable and cannot facilitate performance. Given the symmetry of interference on *Different* trials, the substantial facilitation for the LVF and none for the RVF on *Same* trials implies a LH advantage for inattentive processing of contralateral syllables (Model 2A), as there is for attentive processing. Facilitation for the LVF is restricted to P3 and there is no facilitation in either field for P1 or P2. There may be a floor effect that precludes facilitation on *Same* relative to *Neutral* trials due to the low error rates for P1 and P2 on the latter.

Although the degree of interference on *Different* trials is independent of the accuracy with which *Different* distractors are encoded, the frequency of *identifiable* intrusions depends on the accuracy of their transcallosal codes. The frequency of identified intrusions relative to total *Set* errors (or *Set* + *Non-Set*) is greater into the LVF than RVF (Fig. 5), which confirms a LH advantage in inattentive processing. The higher rate of intrusions for vowels (P2) than consonants (P1 and P3) may reflect an under-correction of the vowel intrusion rate. If the unattended P1 letter is correctly encoded, it contains information about the P2 vowel since different vowels had different frequencies of association with consonants at P1. To the extent that participants learned these associations, vowel intrusions were inadequately corrected for guessing.

Identified intrusions on *Different* trials are greater into the LVF than RVF for the first (P1) and third (P3) letters and symmetric for the vowel (P2). This implies that inattentive processing of P1 and P3 is more accurate in the RVF than LVF. These results stand in contrast to error patterns for attentive processing, in which P1 is more accurately processed in the LVF than RVF, and suggest that inattentive processing by the LH entails more integral (global, parallel) encoding, with a flatter error function, than does attentive processing.

In summary, we reach the following conclusions. First, the LH neither inhibits the RH nor blocks transcallosal input on the syllable task. Rather, transcallosal codes of unattended syllables are transmitted from each hemisphere to the other and the transmission is just as efficient from the RH to LH as vice versa. Second, there is a RVF advantage in inattentive syllable processing, as for attentive processing, but asymmetric encoding strategies are *not* the same for inattentive as for attentive processing.

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