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Notes and Comment

Adaptation effects and reversible figures: A comment on Horlitz and O'Leary

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In a recent article, Horlitz and O'Leary (1993) offer a reinterpretation of the results of several studies over the past 40 years that have employed the prolonged-inspection technique in the investigation of reversible figures. Specifically, they contend that, contrary to the favored interpretation of neural adaptation effects, the results of these studies reveal the combined influence of such top-down processes as attention and perceptual learning as well as such methodological difficulties as unwanted demand characteristics. In this note, we examine their analysis of the literature, their alternative theoretical model, and the supporting conclusions they draw from their two experiments. We argue that there is considerable evidence from a variety of studies for the joint role of bottom-up and top-down processes in reversible figures. Moreover, we propose that Horlitz and O'Leary's own research, rather than eliminating the possibility of neural-adaptation effects, is best conceptualized as providing additional evidence for the role of higher-order processes in these phenomena.

In a recent article, Horlitz and O'Leary (1993) propose an alternative explanation for the reversibility of ambiguous figures to the one currently favored by several studies that have employed a popular methodology. Specifically, they take to task proponents of neural-adaptation models who have posited a critical role played by the fatigue and recovery of those neural structures that underlie the two (or more) percepts of a reversible figure. These models (in various forms) can be traced back at least to the Gestaltists who argued that a buildup of cortical "satiation" is responsible for the phenomenal reversals (e.g., Kohler & Wallach, 1944). Post-Gestalt researchers preferred to discuss the accumulation of neural fatigue over extended viewing of a reversible figure (Hochberg, 1950; Howard, 1961). In this view, as one perceptual organization of the figure dominates, the neural structures underlying that percept experience a buildup of fatigue, eventually resulting in a switch to those neural structures underlying the alternative percept. This neural alternation is the presumed basis for the phenomenal reversals.

As Horlitz and O'Leary note, some of the strongest empirical support for neural-adaptation models[1] over the past 40 years has come from several studies employing the "prolonged-inspection technique" (most readers may be more familiar with the term "selective-adaptation paradigm"[2]). In the application of this procedure to reversible figures, the subject is initially shown (or adapted to) an *un*ambiguous version of the reversible figure. Upon inspection of the traditional (i.e., ambiguous) reversible figure during a subsequent test phase, the subject is much more likely to report the alternative version of the figure, presumably because the unadapted structures underlying that percept will be dominant (e.g., Carlson, 1953; Harris, 1980; Hochberg, 1950; Long, Toppino, & Mondin, 1992; Nawrot & Blake, 1989; Virsu, 1975; von Grünau, Wiggin, & Reed, 1984).

Horlitz and O'Leary's criticisms focus on this particular procedure and, by extension, on the likely role of passive neural processes in the reversibility of these popular figures. Their criticisms take several forms. First, they argue that several findings in the literature are clearly incompatible with a strict neural-fatigue model of reversible figures. Second, they cite particular studies that have ostensibly employed the same prolonged-inspection technique but have obtained evidence that is inconsistent with the neural model. Given these points, Horlitz and O'Leary propose an alternate interpretation of the prolonged-inspection technique. In their view, the observer in the traditional adaptation study is able to retrieve the alternative percept while examining the unambiguous figure during the inspection period via access to the previously stored alternatives in memory. Moreover, this alternative percept to the one being viewed "gains perceptual strength through processes such as imagination or memory" (p. 668). With the help of additionally hypothesized mechanisms, this results in the adaptation-like bias for observers to report the alternative percept in the test period. Finally, to support these claims, Horlitz and O'Leary present data from two experiments that they believe reveal the role of critical top-down processes, such as familiarity and attention, on the reported reversals of reversible figures following prolonged inspection. We shall consider each class of criticism in turn.

Limitations to a Neural-Adaptation Model: Status of Empirical Evidence

There are several empirical results, some of which were cited by Horlitz and O'Leary, that necessitate the inclusion of top-down processes in phenomenal reversals. Four classes of findings can be cited in this regard. First, it has been reported that performance on a secondary task during the inspection of a reversible figure

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tends to slow the rate of figural reversal (Reisberg & O'Shaughnessy, 1984). This is thought to indicate that some attentional capacity is required for figural reversal, and, as such, contrasts with a strict view of passive fatigue-like processes as the basis for reported reversals. Second, it has been demonstrated that an observer's knowledge of the ambiguous character of a reversible figure affects the likelihood of reported reversals of that figure (Girgus, Rock, & Egatz, 1977; Rock & Mitchener, 1992). Hence, an important role for the expectations of the observer is indicated. Third, several studies have reported that altering the instructions given to subjects can alter the rate of reported reversals (e.g., Hochberg & Peterson, 1987; Pelton & Solley, 1968), suggesting a strong role for subject intention or strategy. And finally, practice effects with these figures in the form of elevated reversal rates over widely separated trials would appear to disprove the sole involvement of transient adaptation effects in figural reversal (e.g., Long, Toppino, & Kostenbauder, 1983; Mefferd, Wieland, Greenstein, & Leppman, 1968).

On the other hand, several alternative empirical results, independent of the selective-adaptation efforts, also exist that reveal the probable role of lower-level processes in reversible phenomena, a role that was not addressed by Horlitz and O'Leary. First, the consideration that side-by-side reversible figures can reverse independently of one another and can be adapted independently of one another suggests the role of relatively independent and localized structures (e.g., Howard, 1961; Long & Toppino, 1981; Long et al., 1983; Toppino & Long, 1987; von Grünau et al., 1984). Second, the number of reversals reported in successive viewing periods of a session exhibit repeated, negatively accelerating patterns of reversal, indicative of passively recurring cycles of fatigue and recovery (e.g., Babich & Standing, 1981; Brown, 1955; Howard, 1961; Long et al., 1983). Finally, it has been noted that shifting the retinal locus or the retinal size of a reversible figure after prolonged viewing lowers reversal rates to initial starting levels (e.g., Howard, 1961; Petersik, Shepard, & Malsch, 1984; Toppino & Long, 1987; von Grünau et al., 1984). Hence, once again, very localized effects are revealed rather than the more global influence that might be expected of top-down processes.

The point of this brief review is to demonstrate that neither a model based on passive fatigue-like processes nor a model based on active information processing or perceptual learning is sufficient *on its own* to encompass the extensive reversible-figure literature. Moreover, this point has been emphasized repeatedly by several writers who propose more eclectic positions that allow for both top-down and bottom-up processes (e.g., Hochberg & Peterson, 1987; Long et al., 1983; Long et al., 1992; Palmer & Bucher, 1981; von Grünau et al., 1984). The "either/or" character of much of the earlier work has given way to less extreme models that permit input from multiple sources. In fact, in an article cited by Horlitz and O'Leary as favoring the exclusive role of passive neural processes, we made the explicit argument that "a full account of reversible-figure phenomena may require some sort of multilevel theory involving both local and global processes. Thus relatively local processes, such as those for which we have provided evidence in the present paper, might feed into and/or be coordinated by more global, perhaps decisional mechanisms" (Toppino & Long, 1987, p. 47).

The Problem of Empirical Discrepancies with the "Prolonged-Inspection Technique"

Horlitz and O'Leary are particularly impressed by those early studies (e.g., Botwinick, 1961; Epstein & Rock, 1960; Leeper, 1935) that used the prolonged-inspection technique but found the subject to report the inspected configuration (rather than the uninspected alternative predicted by a strict adaptation model) during the test phase. They attribute this inconsistent result to the critical role played by the observer's knowledge of the reversibility of the figure, stating that "different mechanisms were engaged during the inspection phase, depending on the subject's access to information" (p. 669). Furthermore, the several studies that obtained clear adaptation results over a 40-year period are hypothesized to suffer from strong "demand characteristics" that induced subjects to report the uninspected alternative during the test phase (p. 670). No evidence is used to support this extreme claim. Nonetheless, Horlitz and O'Leary believe that these examples that apparently contradict the adaptation results provide critical support for a reinterpretation of the processes underlying the effect of prolonged inspection in favor of learning and expectation.

While such an interpretation is indeed possible, it should also be noted that an alternative proposal has recently been suggested by Long et al. (1992). They propose that both passive, adaptable processes and higher-order cognitive processes may contribute to reported reversals of an ambiguous figure and that the relative degree of contribution may be determined by critical stimulus and instructional variables. With specific regard to the apparent discrepancies in the prolonged-inspection literature, Long et al. suggest that the critical difference across studies may be the *duration of the inspection period*. In those earlier studies in which set-like (as opposed to adaptation-like) effects were reported, brief inspection periods appear to have been common, while in the work that reported adaptation-like effects—especially the more recent work explicitly borrowing the selective-adaptation paradigm from the vision literature—rather long inspection periods were the norm (e.g., Long et al., 1983; Nawrot & Blake, 1989; Petersik et al., 1984; Toppino & Long, 1987; von Grünau et al., 1984).

To test this prediction of the moderating influence of inspection duration, Long et al. (1992) systematically varied the duration of the inspection period between 5 and 180 sec. They found that for both the overlapping-

squares reversible figure and the three-dimensional rotating Necker cube figure, brief inspection of an unambiguous version of the figure resulted in classic set effects, whereby the subject was more likely to perceive the reversible figure in the *same* configuration as that of the inspection figure. In contrast, long inspection of an unambiguous version of the figure resulted in classic adaptation effects, whereby the subject was more likely to perceive the reversible figure in the *opposite* configuration from that of the inspection figure. Long et al. interpreted this pattern of results as further evidence for the role of both top-down and bottom-up processes, the relative importance of each depending upon viewing conditions. They concluded that "figural reversals may reflect in an especially powerful way *both stimulus-driven and conceptually-driven processes* and may therein serve to reveal the nature and interaction of these two levels of processing" (p. 615, italics in original).

It would thus appear that there exists a reasonable alternative to the suggestion by Horlitz and O'Leary concerning the basis for the discrepant results in the literature. Furthermore, this alternative explanation, which maintains the validity of neural-adaptation effects *under appropriate conditions*, has some strong empirical support.

Horlitz and O'Leary's Theoretical Alternative: The Changing-Availability Model

The previous sections have provided a more complete review of the reversible-figure literature, as well as an empirically based reinterpretation of discrepant results. Taken together, these points raise serious questions about the validity of excluding an important role for passive neural processes from the theoretical account of perceptual multistability. Nonetheless, while providing a broader context in which to evaluate the claims made by Horlitz and O'Leary, these arguments do not necessarily bear directly on the ability of Horlitz and O'Leary's theoretical model to predict the specific results from the prolonged-inspection technique. If the converging evidence from other work is ignored, how does the Horlitz and O'Leary explanation fare on its own merits?

It is our contention that the theoretical rationale offered by Horlitz and O'Leary to account for the numerous empirical results obtained with the prolonged-inspection technique is unconvincing at best, since it is clearly post hoc in nature and does not seem to account adequately for existing data. In their view, prolonged inspection of an unambiguous version of the reversible figure allows observers to access *both* alternatives of a reversible figure through "high-level analysis of the figure, resulting in the accessing of multiple memories" (Horlitz & O'Leary, 1993, p. 670). That is, while viewing the unambiguous stimulus alternative during the inspection period, observers are assumed to retrieve and process the noninspected alternative; moreover, this is assumed to be done spontaneously by observers without instruction from the experimenter. However, there is little independent support for this changing-availability hypothesis, and Horlitz and O'Leary do not even offer subjective reports from their own subjects to bolster their claim (which goes directly counter to our impressions).

Putting aside the putative nature of these claims, the increased availability of both alternatives during the prolonged inspection of either one alone should result in increased ambiguity in response to the subsequent (ambiguous) test figure; this, however, is not the case. Therefore, to account for subjects' increased likelihood of reporting the alternative configuration in the test period, Horlitz and O'Leary introduce the additional factors of habituation and preference for novelty. Presumably, experience with the unambiguous stimulus during the inspection period results in habituation of that stimulus configuration. Consequently, observers, who are assumed to prefer novel stimuli, are attracted to the alternative, comparatively novel stimulus organization when the ambiguous figure is subsequently exposed.

Once again, Horlitz and O'Leary cite no independent evidence either to indicate that their post hoc habituation/novelty mechanism is a viable hypothesis in the present context or to suggest that this mechanism should be preferred over the neural-adaptation mechanism that has been proposed by others. Indeed, the two hypotheses, although stated in different terms, even appear to be functionally quite similar. However, in an attempt to distinguish the hypotheses, Horlitz and O'Leary state that their proposed mechanism "is not a process that is . . . location specific—as argued by Toppino and Long (1987)—or that requires lengthy fatiguing of neural channels" (p. 680). Unfortunately, this puts their hypothesis at odds with the data: First, it is a well-established empirical finding that the effects of prolonged inspection are location specific (e.g., Toppino & Long, 1987; von Grünau et al., 1984); and second, it is clearly established that lengthy exposure to an unambiguous stimulus during the inspection period is necessary to produce preference for the alternative configuration when the ambiguous stimulus is subsequently presented (Long et al., 1992). Thus, Horlitz and O'Leary's post hoc habituation/novelty hypothesis may not account for prior findings any better than—or, indeed, even as well as—the neural-adaptation hypothesis which they criticize.

Horlitz and O'Leary's Empirical Support for Their Own Model

To support their argument for an alternative interpretation of the prolonged-inspection results, Horlitz and O'Leary undertook two experiments in which they attempted to demonstrate results with the prolonged-inspection procedure that reveal clear attentional and learning processes. In Experiment 1, they reported that significantly more reversals were reported in a 10-sec test period if observers were given extensive experience with the ambiguous figures (during a previous learning phase) and actively attended to the reversible figures

during the inspection period. In Experiment 2, they varied the degree of observers' familiarity with the figures, as well as the theoretical accessibility of the two alternatives during the inspection phase, and found that both variables tended to moderate observers' responses to the ambiguous figure. They concluded that their results did not support a neural-fatigue model and were more directly consistent with the hypothesis that "as the amount and availability of information regarding the alternative percept increased during the inspection phase, so did the perceptual instability of the figure" (p. 678).

We have two particular concerns about Horlitz and O'Leary's experiments, one procedural and one interpretive. First, in their experiments, the duration of the "prolonged" inspection was 60 sec in Experiment 1 and 10 sec in Experiment 2. These are very brief periods in which to adapt neural structures. As noted above, those studies that have employed the selective-adaptation paradigm both in the general investigation of proposed neural channels (e.g., Blakemore & Campbell, 1969; Blakemore & Sutton, 1969; Magnussen & Johnsen, 1986) and in the specific investigation of reversible figures (e.g., Nawrot & Blake, 1989; Petersik et al., 1984; Toppino & Long, 1987) have routinely used adaptation periods of several minutes. In the previously cited study by Long et al. (1992) in which the duration of the adaptation period was systematically varied, evidence for adaptation effects was absent at durations of less than approximately 100–120 sec. More recently, Long and Toppino (in press) found that even a 2-min adaptation period produced only modest evidence of adaptation with a rotating-trapezoid illusion, but that a 5-min adaptation period produced very strong evidence for such effects. Our basic point here is that there is good reason to assume that the conditions employed by Horlitz and O'Leary were not sufficient to produce appreciable adaptation effects—especially if they seek to rule out the possibility of such effects in other studies as well. The comparability of their procedures (and their subsequent findings) to the bulk of adaptation studies they cite is suspect.

To bolster this argument, we point to the fact that in Horlitz and O'Leary's Experiment 1, no effects of the various treatment conditions were obtained for two of the three dependent measures examined. Neither the duration for which the alternative configurations was reported nor the first percept reported in the test interval exhibited the pattern of results predicted by Horlitz and O'Leary's (1993) reinterpretation of the prolonged-inspection procedure ($F < 1.0$ in both cases). Only the mean number of reversals reported in the test period varied across the experimental conditions. In Experiment 2, the mean number of reversals and the initial percept did follow the predicted pattern across the experimental conditions, but the mean duration again failed to follow predictions. These results are troublesome not only because of their obvious lack of consensus but also because the one dependent measure (the mean number of reversals) that was most consistent with their predictions has been found to be particularly sensitive to stimulus factors, such as size, as well as to procedural conditions, such as practice (Long et al., 1983; Long et al., 1992).

However, even more damaging to Horlitz and O'Leary's argument is an interpretive point, concerning the fact that the absolute levels of their dependent measures in both experiments never exhibited adaptation-like effects, even under the experimental conditions that ostensibly mimicked those of the classic adaptation studies.[3] Specifically, in Experiment 1, the alternative configuration was reported in the attention/familiar condition for about 4.4 sec of the 10-sec test interval, and it was reported as the initial percept on only 43% of the trials. In Experiment 2, under the strongest adaptation condition, these two values were, respectively, 14.8 sec of the 30-sec test interval and 47% of the trials. Neither variable in either study revealed any hint of the typical bias routinely reported with the prolonged-inspection technique. Hence, we would argue that these results support the contention that the conditions chosen by Horlitz and O'Leary were insufficient to reveal the adaptation processes they were questioning. The obtained results are thus best conceptualized as revealing the effects of familiarity, attention, and priming on certain aspects of subjects' phenomenal reports of a reversible figure *when adaptation effects are minimized.*

Our second reason for advocating caution in the interpretation of the Horlitz and O'Leary results is more theoretical and rests on recent findings in the adaptation literature which indicate that attention may moderate adaptation effects. For example, Chaudhuri (1990) found that if observers are engaged in a separate discrimination task superimposed on a moving pattern, the subsequent motion aftereffect to that pattern is greatly reduced in comparison with that obtained in more typical viewing conditions. Shulman (1991) demonstrated that reports of a motion aftereffect (counter to the direction of the adapted motion) depended upon whether an observer attended to critical portions of the adaptation stimulus during the inspection phase. Of direct relevance in the present context, Hochberg and Peterson (1987; Peterson & Gibson, 1991) have argued that the powerful effects of attention and instructions (i.e., intention) that they have found with ambiguous figures are best conceptualized as being superimposed on more automatic, peripheral processes. Likewise, according to Cavanagh (1992), who has recently suggested a similar notion to accommodate the observer's perception of motion under a variety of conditions (such as conflicting motion cues), "many neurons in primary visual cortex are sensitive to the direction of motion and attention might act by selecting one or the other of these low-level motion responses" (p. 1563).

Hence, we are proposing here that, even if longer adaptation durations were used to overcome our previous objection concerning the inadequacy of the experimental conditions, any consequent adaptation effects may be

subject to substantial attentional mediation. That is, the attenuation of adaptation effects under some particular set of conditions would not demonstrate the lack of involvement of such effects under others. Quite simply, then, the "either/or" argument by Horlitz and O'Leary may be too narrow to encompass the complexity of the phenomena because it presumes the mutual exclusivity of sensory and cognitive processes.

Summary

Horlitz and O'Leary have provided further evidence for the important role of such top-down processes as attention and familiarity on reported reversals of ambiguous figures. As such, these results are consistent with the claims of several other investigators who have argued that any theory of phenomenal reversal that is based solely on passive neural processes is likely to be incomplete. However, Horlitz and O'Leary make the additional claims (1) that the several reports of adaptation effects in the literature are readily reinterpreted within an information-access framework and (2) that their own empirical work demonstrates a basic failure of neural-adaptation effects with reversible figures. It is proposed here that these claims must be viewed with caution.

First, Horlitz and O'Leary's explanation for the discrepancy of their results from those of ostensibly similar experimental procedures in the reversible-figure literature is not the only, or the most likely, possibility. A plausible alternative model that posits critical procedural differences (specifically, duration of adaptation) across studies has been offered, and supporting empirical work for this latter suggestion has been presented. Second, the empirical efforts of Horlitz and O'Leary, while providing further evidence for top-down processes, do not eliminate the likely role of adaptation effects with reversible figures. There is strong reason to believe that the viewing conditions selected by these researchers may not have been sufficient to produce appreciable adaptation. Moreover, there is excellent reason to believe that *both* bottom-up *and* top-down processes moderate reported reversals of these figures. If one accepts a hybrid model of phenomenal reversal, as proposed by several investigators over the past dozen years, the demonstration of attentional and familiarity effects does not preclude the possibility of lower-level adaptation effects as well. We would argue that, currently, the latter view is more consistent with the extensive reversible-figure literature than is the exclusively higher-order model favored by Horlitz and O'Leary.

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NOTES

1. Many current researchers prefer the term "neural adaptation" to the older expression "neural fatigue," since it allows for either within-channel fatigue or between-channel inhibition, or for both, as the basis for adaptation effects. Consequently, this more neutral term will be used here as well.

2. It should be noted that the effects of prolonged inspection on an individual's subsequent perception of a target have an interesting history in the perception literature. In an earlier article, Long (1988) discussed two ostensibly similar procedures, namely, the selective-adaptation paradigm and the transfer-of-decrement paradigm, which often result in very different interpretations from ostensibly similar procedures.

3. We are indebted to an anonymous reviewer for bringing this point to our attention.

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