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CHAPTER 7

Subliminal Perception: Nothing Special, Cognitively Speaking

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Intrigue with the suggestion that humans have subliminal perception is evidenced by the tremendous literature and continuing controversy on the topic. Merikle and Joordens (chapter 6, this volume) and Greenwald and Draine (chapter 5, this volume) have made significant contributions to this literature and to methodologies aimed at gaining further understanding of subliminal perception or subliminal semantic activation.

The basis for the persistent interest in establishing evidence for subliminal perception ranges from theoretical interest of psychologists in the elusive nature of consciousness to the pragmatic interest of those who would hasten to capitalize on the phenomenon were the evidence unequivocal. Yet the theme of this symposium gives us a more general explanation of the interest in the phenomenon of perception without awareness: Cognitive psychology strives to understand the underlying mechanisms giving rise to cognition—to what extent can we tool our instruments and methodology to observe effects on behavior of stimuli about which we are unaware? And if it can be established that behavior can be influenced by visual presentations that elude awareness, then is it reasonable to presume that other sources of unconscious influence also affect behavior? Finally, can the influence of unconscious cognitive processes be explained within the same general framework one adopts to explain conscious processes, or will tapping into processes unaware to the perceiver require architectural assumptions or mechanisms heretofore unnecessary?

METHODOLOGICAL ISSUES

Central to the current issues surrounding this topic is the question of how to determine when a stimulus is truly subliminal. This is the quagmire that Merikle and Joordens and Greenwald and Draine have addressed, and one that has kept the research area of unconscious perception in a state of controversy for decades. After an extensive review of the extant literature in three basic paradigms (visual masking, dichotic listening, and parafoveal vision), Holender (1986) concluded that existing methodology was simply not sufficient to demonstrate semantic activation without conscious identification. Trying to demonstrate null sensitivity on a direct detection measure in order to prove that an effect on a second, indirect measure was caused by an unconscious process is, in essence, like trying to prove the null hypothesis: There is always the possibility that some amount of stimulus information was detected on at least some occasions that eluded detection by conventional subjective or objective measures.

Merikle and Joordens cogently argued that it is virtually impossible to conceive of an exhaustive measure of unconscious influence, and to convincingly demonstrate null sensitivity on that measure. Both groups of researchers abandoned trying to demonstrate subliminal perception by the traditional methods critiqued by Holender and took great strides to move the methodology forward. In many ways their solutions share the same spirit in the way they finesse the problem statistically and methodologically.

Merikle and Joordens developed an elegant technique of using Jacoby's exclusion task (Debner & Jacoby, 1994; Jacoby, 1991) to obtain clearly different patterns of stem completion conditional on exposure duration. Jacoby's exclusion task involves instructing subjects to complete a word stem, such as "tab__," with any word that comes to mind other than the preceding prime word ("table"). Jacoby found that at short stimulus onset asynchronies (SOAs of 50 ms), subjects were unable to exclude the prime in their response. By manipulating the SOA between the onset of the prime word, and the onset of the mask, over a range of 0 to 214 ms, Merikle and Joordens were successful in determining the critical stimulus duration at which the unconscious influence of the prime exceeded the conscious influence of the prime (to comply with instructions to exclude the prime word). Furthermore, they have successfully used this crossover point (the critical stimulus duration) at which the relative magnitude of unconscious influence of a percept exceeds conscious influence to predict the critical exposure duration necessary for unconscious perception to influence responses in a completely different task, the two-color Stroop task. In addition, Merikle and Joordens found significant (albeit modest in magnitude) correlations between performance on the exclusion task and the size of the Stroop effect. Thus, Merikle and Joordens demonstrated that both qualitative and quantitative predictions can be made on the basis of a measure

of the relative influences of conscious and unconscious influences. They concluded that the exclusion task is a satisfactory measure of these relative influences. Merikle and Joordens succeeded in moving this area of research forward in both methodological development and the use of statistical techniques to establish converging evidence between task domains.

Like Merikle and Joordens, Greenwald and Draine moved beyond attempting to prove there is no conscious component in subliminal perception, to a method that analyzes the regression relation between direct and indirect measures of responses to near-threshold stimuli. Conditions were designed such that subjects could perform on a continuum from less than chance to greater than chance accuracy on direct measures of conscious perception (d'), as measured on a lexical detection task of four-letter stimuli presented under conditions of dichoptic masking. An important manipulation was the occasional flash of the word (LEFT) or the non-word (RIGH). Tendencies to respond with the left index finger (intended for nonword responses) to the word *left* or with the right index finger to the nonword *righ* were viewed as unconscious influences.

Collecting data from over 2,000 subjects in 20 experiments, Greenwald and Draine used two values of d'. Objective accuracy at discriminating words from nonwords was the direct measure. The indirect measure involved computing d' differently: Erroneous responses in which subjects pressed the right key (intended for words) for R-I-G-H were treated as hits, and those same presses for the word LEFT were treated as false alarms. They regressed performance on the indirect measure against the direct measure (as the predictor). The critical result was to find an intercept that was significantly greater than zero. Although Greenwald and Draine are to be commended on taking a fresh approach to their investigation of unconscious influences, their statistical methods rely on assumptions that are not fully met by the data.[1] Greenwald and Draine argued that the critical result for demonstrating unconscious influences is a positive value of the intercept measuring the stimulus word influence (left, righ) on position response. Although the positive intercept is consistently found in their regression models, the use of the regression techniques in this instance seems problematic despite their claims to the contrary. Nevertheless, Greenwald and Draine's technique offers promise as yet another method for surpassing the limitations of earlier methodology in the investigation of nonconscious perception.

Where do we go from here? These data from Merikle and Greenwald's laboratories with their improved methods for investigating the phenomenon of subliminal perception are convincing evidence that such a phenomenon exists. Now we are in a position to ask how and why they occur. It is important to

[1] Particularly problematic is the necessary assumption that there is no measurement error in their predictor variable.

explore how we can understand these effects in terms of a general, theoretical framework.

THEORETICAL ISSUES

Holender (1986) went beyond the issue of criticizing the extant methodologies' ability to demonstrate subliminal perception: He decried the absence of any theoretical framework in which such phenomena could be explained. Morton (1986), however, asserted that Holender's position was not justified. Morton pointed out that subliminal effects could be accommodated within a variety of existing information-processing models (including very early versions of Morton's own logogen model; e.g., Morton, 1986), without concern about the specific nature or definition of "consciousness."

In the spirit of Morton's commentary, the viewpoint we would like to propose is that *subliminal perception is nothing special, cognitively speaking.* It can be explained and subsumed by a general cognitive architecture, the mechanisms of which produce comparable results in many other task domains. The remainder of this commentary focuses on how to understand phenomena such as subliminal perception as merely a specific instance in a general cognitive architecture.

ASSUMPTIONS

The assumptions come from the SAC model of memory (Reder & Schunn, 1996; Schunn, Reder, Nhouyvanisvong, Richards, & Stroffolino, in press). This model bears similarity to a class of frameworks (e.g., ACT*, Anderson, 1983; and CAPS, Just & Carpenter, 1992). The differences among these theories or frameworks is probably not of importance for accounting for these phenomena. The following are the most essential assumptions in this context:

1. Memory is organized into a perceptual and semantic network of connected ideas, with each concept node in memory varying in base strength, transitory strength, and short-term activation, all as a function of environmental or internal (self-activation) exposure.
2. The base strength of a concept can be thought of as its resting level of activation. The strength of a connection between two concepts is independent of the strength of the concepts that are connected by it.
   **For a concept to be in conscious awareness, its activation must be above threshold. Magnitude of activation is partly a function of the exposure duration of the stimulus.
   **Availability of a concept is a function of its current level of activation.

That is, the ease with which a concept may pass over threshold depends on its resting level of activation.

3. In addition to a declarative memory that sends out activation effortlessly, there is a more controlled processing mechanism that represents strategic decisions or rules, such as "whenever you see a red traffic light ahead of you, stop your car." The execution of these rules vary in their time to "fire" (execute an action). Actions are not necessarily motoric. They may include goal setting or activating something else in declarative memory. **The speed with which a production rule can fire is partly a function of the level of activation of the elements it tries to match in its condition clauses.

With these few assumptions, we can explain a number of phenomena as well as subliminal perception (see Reder & Schunn, 1996, for a fuller explanation), and show that subliminal perception can be understood as a result of routine cognitive functioning, and does not really behave in an exceptional fashion.

Exclusion Task

In light of the assumptions just enumerated, consider first the exclusion task performed by Merikle and Joorden. As in Jacoby's experiments, the subject is subliminally primed with "table" and then asked to complete the word stem, "tab__." When presented for a very short duration, "table" gets only partially activated. As a result, when asked to complete "tab__," "table" becomes available more easily than other words.

Whether presented subliminally or for a longer duration, table is more available as a completion if it was so primed. In addition, there is the explicit rule (special purpose production that is set up based on instructions): *If the word you think of was just seen, do not use it for the completion.* For that rule to be followed subjects must of course be consciously aware of the previous presentation. Therefore, when the word "table" is presented for a longer duration it exceeds the threshold for conscious awareness, and a context tag is generated, from another production rule: *If I recognize the word that is flashed, generate a context tag for it so that I do not use it for the completion task.* "Table" is still activated first when presented with the "tab__" stem, but it is not explicitly used as the completion because it has been tagged as having been seen and thus the condition for the Exclusion rule is fulfilled—that is, the action is to respond with any word other than "table."

Note that this explanation predicts that subjects will take *longer* to complete the stem with any other word than with table.[2] That is because they think of table in both cases.

[2]Unfortunately, those data were not provided.

Stroop Task

The experiment described by Merikle and Joordens as a two-alternative, red/green, forced-choice Stroop task, was sometimes structured so that the probability of an incongruent prime-target pair was three times as probable as a congruent prime-target pair. When the prime "RED" preceded the opposite color (green) target 75% of the time, the subject learned to expect that a color word meant the opposite color target was more likely to occur. In this situation, a supraliminal color cue had the opposite effect of a subliminal color cue: If the color word prime was not consciously detected, the congruent color was facilitated in a choice reaction time; however, when the prime was consciously detected, there was facilitation for the opposite color, and corresponding inhibition for the matching color.

Our explanation is that subjects develop an adaptive rule (in our model, a production rule) that states: If "red" is flashed, prime (activate) "green" and dampen (inhibit) "red." A complementary production for "green" is also created as the subjects learn the contingencies.

The key point is that these productions cannot fire in time if the color word is only briefly flashed. There is not enough stimulus energy to get the production to fire and thus to prime the opposite word, before the color patch is presented. The speed with which productions fire is a function of the production's strength and the activation level of the nodes that match its condition elements. Other productions were also created—for example, when the ampersands are colored red, press the left key that is labeled "red." The subliminal prime of the word *red* will raise the activation level of the "red" term in the production to push the red button, although it is not sufficient to actually get the production to fire—nor should it, because primes are not always accurate, and thus there would be too many errors.

It is important to note the explanatory connection between the pattern of results and the subliminal flash. The basic notion is that the subliminal flash raises the activation of the corresponding element, but not enough to reach threshold. Productions cannot fire without the elements passing threshold (hence the production to "prime" or activate the opposite color cannot fire), but a subliminal flash can raise the current activation level of an element enough to make it easier to fire a production later.

In other words, under conditions of below-threshold activation of the color word there is enough activation to raise the level of the word element "red" so that when the color red is seen, the production will apply faster, enabling the subject to press the red button faster. In contrast, the production that enables anticipation (the priming) of "green" will not fire unless the elements reach threshold—the opposite color cannot have its activation raised (nor inhibit the congruent color) unless a production fires.

Note that this type of explanation does not depend on external, subliminal

perception. Rather, it depends on below-threshold activation (that could arise from internal stimulation) and the concomitant inability of the production to fire. The same result would occur if for some other reason the production could not fire fast enough to inhibit the congruent response. Indeed, a classic result of Neely (1977) involving priming in a lexical decision task can be explained with similar assumptions.

LEXICAL DECISION

In Neely's experiments, subjects were instructed to make lexical decision judgments for word and nonword targets preceded by a prime. The prime could either be semantically and categorically related to the word (e.g., BIRD-sparrow) or unrelated (e.g., BIRD-popsicle). In addition, subjects were explicitly instructed that a nonsemantic, experimental relation had been constructed for some of the primes. Specifically, when the prime "BODY" was presented, a building part, such as "door," was likely to be given as a target to be judged; likewise, when subjects saw "BUILDING," they were likely to see a body part, such as "arm" as the target. Lexical items from the category of body parts were not always preceded with the prime "BUILDING," nor were building words always preceded with the prime "BODY"; however, the proportion was the same as in the case of the opposite cuing of Green to Red described earlier.

Whether there was facilitation in lexical decisions (faster decision times compared with conditions involving a neutral prime of xxxx preceding the target) depended both on the relation of the prime to the target and the SOA (lag from prime to target) between them: Semantically related prime-target pairs produced facilitation at the shortest SOA (250 ms), but inhibition at the longest SOA (750 ms) if they expected the other category of words (i.e., in the "shift" condition); unrelated, but expected, pairs such as "BODY-door" on the other hand, produced the complementary results: Facilitation increased with increasing SOA. Thus, as in Merikle and Joordens' data, at short SOAs, automatic processes (spreading activation between semantic associates) dominate strategic processes (the firing of a production rule created by instructions); long SOAs, however, provide time for the production rule to fire that states "when I see the word *BODY* think of *building parts*," and to shift activation from the automatically primed word to the new focus of attention.

The important point, from our perspective, is that the aforementioned results mirror those for the Merikle and Joorden results in that SOA maps onto duration of the flash. With short SOAs or brief exposures, there is not enough time or activation for the strategic production to fire. Only automatic activation (not caused by special-purpose, experiment-specific productions) can occur in this context.

It is also important to mention that Merikle and Joordens actually confounded SOA and duration of the flash. We have been supposing that their results occurred because the duration of the flash was not long enough to achieve sufficient activation; however, because the offset of the prime was confounded with the onset of the colored ampersands, it is conceivable that there simply was not enough *time* to fire the production that would prime the other color. In other words, the comparison with the Neely study may be even more direct.

The result that performance can be affected by manipulations about which the subject is *unaware* have made people feel that there was something magical about subliminal perception. However, such results occur in many arenas besides subliminal perception, and not just in those described earlier. Misattributions of familiarity occur in a wide variety of situations (see Jacoby, Bjork, & Kelly, 1994; Kamas & Reder, 1994, for fuller discussions).

Savings in re-learning is another example of a phenomenon that can be thought of in these terms, although it has not heretofore been characterized in this way. Specifically, savings in re-learning is a situation where a person learns (relearns) information encountered previously that could not be recollected or recognized and from the subject's perspective might well never have been presented prior to the new learning situation. In this paradigm, the information might be a list of words that when tested 6 months later seems to have left no memory "trace." Nevertheless, this previously presented list can be learned faster than a new one. This can be explained in terms of residual activation of the connection from the word units to an experimental node (experimental context) that has fallen below the threshold for awareness, yet remains at a level sufficient to be strengthened and thus facilitates relearning.

Merikle and Joorden's Correlations

The correlations between performance on the exclusion task and the size of the Stroop effect found by Merikle and Joordens were modest. One reason for the low correlations may be the size of the Stroop effects they obtained. Although statistically significant for different SOAs, the mean Stroop effect was only approximately 20 ms at the critical stimulus duration, and 12 ms at the longest stimulus duration. Thus, the magnitude of the correlations between the Stroop effect and performance on the exclusion task was restricted by the range of these Stroop effects.

Other factors too may have influenced the relatively weak correlations. Although individual differences in ability to perceive the words should increase the correlation across the two tasks, other variables that differ among individuals are not shared by the Stroop and exclusion tasks. For example, people probably vary in the strength of their productions to prime the incongruent color in the Stroop task. The strength of those productions will influence re-

sponse time in the corresponding conditions. Likewise, people probably differ in their baseline strength or resting activation level of words that are subliminally flashed in the exclusion task. Those differences in resting activation levels will translate into performance differences, but only in the exclusion task. Differences in baseline activation levels and differences in strength of productions are probably uncorrelated among individuals, thus reducing the size of the correlation between the two tasks.

CONCLUSIONS

This commentary claims that the same mechanisms are operating in many arenas and show the same general pattern. Through discussion of data from several different experimental paradigms it has been illustrated that subliminal perception is really only an instance of a more general mechanism. If stimulus energy is insufficient to pass threshold, the words (elements) cannot be in the focus of attention. Partially activated elements that fail to capture attention are also insufficient to activate strategic processes controlled by the firing of production rules created by instructional manipulations. A production can also fail to fire *in time* and therefore have no impact on behavior when the interval between the exposure of an element that is above threshold and the target word (SOA) is very short.

In summary, we believe that research in subliminal perception, with its recent progress in methodology, provides a rich source of fascinating results that are nicely accommodated by current cognitive processing models such as SAC.

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