Perceptual processing of nontargets in an attention task

WILLIAM A. JOHNSTON and JOLYNN WILSON
University of Utah, Salt Lake City, Utah 84112

The capability of nontargets to qualitatively influence the semantic processing of coincident targets was investigated in three experiments. Subjects were aurally presented a series of word pairs and attempted to detect homonymic instances of a predesignated category (e.g., animals). The nontarget with which a target (e.g., ANT) was paired was appropriate (e.g., CRAWLING), inappropriate (e.g., UNCLE), or neutral (e.g., STRAW). Experiments 1 and 2 established that detection of targets can be facilitated by appropriate nontargets and inhibited by inappropriate ones. Thus, nontargets can influence the way in which targets are semantically represented. Experiment 3 showed that this effect is eliminated when subjects are precued as to the ear of entry of targets. Thus, precuing appears to curtail the perceptual processing of nontargets. The data run counter to theories that claim that focused attention does not entail the perceptual suppression of nontargets.

Attention is generally considered focused to the extent that a target stimulus receives more processing than concurrent nontarget stimuli. One class of theory localizes this difference in processing at perception: Target stimuli undergo more perceptual processing than nontarget stimuli because of the perceptual suppression of the latter stimuli. Theories of this class include the early-selection theories of Broadbent (1958, 1971) and Treisman (1964, 1969). Another class of attention theory conceives of the difference in processing between targets and nontargets as being nonperceptual in nature: Target stimuli are accorded priority by a special attention mechanism that operates on the irrepressible buildup of perceptual data for all concurrent stimuli. Theories of this class include the late-selection theories of Deutsch and Deutsch (1963) and Norman (1968).

The trend in recent years has been away from early-selection theories and toward late-selection theories (e.g., LaBerge, 1975; Shiffrin & Schneider, 1977).¹ The decline in popularity of early-selection theories is based, in part, on empirical indications that nontargets in attention tasks are not suppressed but, rather, undergo deep, semantic analysis (e.g., Corteen & Wood, 1972; Lewis, 1970; MacKay, 1973; Shiffrin & Schneider, 1977, Experiment 4). The present research is most closely related to the Lewis (1970) and MacKay (1973) studies.

Lewis (1970) asked subjects to shadow (repeat) words from one of two dichotically presented lists and to ignore words from the other list. The principal finding was that shadowing latency was longer when

coincident target (shadowed) and nontarget ("ignored") words were semantically related than when they were unrelated. Since the response to a target word was affected by the meaning of the coincident nontarget word, Lewis concluded that the nontarget words must have undergone semantic analysis. MacKay (1973) asked subjects to shadow an ambiguous message (e.g., "They threw stones at the bank yesterday.") that was presented to one ear and to ignore any words presented to the other ear. The principal finding, as inferred from subsequent recognition tests, was that the interpretation of the shadowed message was biased in the direction of disambiguating words (e.g., "river" or "money") that were presented to the other ear. Since the interpretation of the target message was affected by the semantic properties of nontarget words, MacKay concluded that the nontarget words must have been processed to a semantic level. In general, this entire line of research reduces the plausibility of early-selection theories by showing that attention to targets does not necessarily prevent the semantic analysis of nontargets.

The present studies extend this line of research. Subjects listened to a series of word pairs and attempted to detect instances of a category such as "articles of clothing." Experiments 1 and 2 sought to determine whether the detectability of a homonymic target word such as "socks" can be either enhanced by a coincident nontarget word such as "smelly" (appropriate nontarget) or hindered by one such as "punches" (inappropriate nontarget). These studies were intended to show that the semantic properties of nontargets can affect the detectability of targets by controlling how they are represented perceptually. Experiment 3 attempted to discriminate between early- and late-selection theories empirically by determining whether a manipulation that increases the overall detectability of targets also reduces the effects on target detectability of appropriate and

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inappropriate nontargets. The reasoning behind Experiment 3 will be developed after Experiments 1 and 2 are presented.

EXPERIMENT 1

Method

Subjects. The subjects were 36 male and female students at the University of Utah. They were recruited from introductory psychology classes and received credit toward a higher grade for their participation.

Procedures. Subjects performed a target-detection task on a succession of nine different lists of word pairs. A list consisted of 81 word pairs, 9 of which contained a target word (i.e., an instance of the target category). The word pairs were presented at the rate of one every 1.5 sec. The interlist interval was 15 sec. A target category was announced 10 sec in advance of each list. The nine target words in a list were homonyms with at least two distinct meanings, only one of which fell within the domain of the target category. Targets were presented at the rate of one in every successive block of nine pairs. Placement of targets in blocks was random, with the restriction that there be at least four word pairs between any two targets.

The manipulation of interest was the nature of the nontarget word with which a target word was paired. An appropriate nontarget was related to the target meaning of the target word, an inappropriate nontarget was related to a different meaning of the target word, and a neutral nontarget was not related to the target word. All three kinds of nontargets were represented, in random order, in each successive set of three targets in a list. Moreover, across subjects, all three kinds of nontargets were represented for each target word. The full set of target and nontarget words used in the experiment is provided in the Appendix. Nine different orders of both lists and target words within lists were represented across subjects.

The subjects served individually in a sound-deadened cubicle. The prerecorded lists were played to subjects from a tape recorder through an amplifier and over stereophonic earphones. Presentation of the word pairs was binaural, rather than dichotic, in that both words in a pair were played to both of a subject's ears. Subjects were instructed to repeat aloud every target word that they detected; their responses were tape-recorded and later scored for accuracy. The task may be considered a divided-attention one, in that subjects had to process both members of each pair in order to detect targets.

Results and Discussion

Across the nine lists, each subject received 27 targets for each type of nontarget. The unit of analysis was the number of targets detected. These units, pooled across subjects and converted into percentages, are summarized in the first row of Table 1. Type of nontarget attained statistical significance in an analysis of variance of these data [$F(2,70) = 4.05$, $MSe = .48$].² A Newman-Keuls

test confirmed the pattern shown in Table 1. Relative to neutral nontargets, inappropriate nontargets reduced the likelihood of detecting targets but appropriate nontargets had no effect on target detections. Although the inhibitory effect of inappropriate nontargets was small in absolute terms, it was highly consistent across subjects.

The inhibitory effect of inappropriate nontargets is consistent with the findings of Lewis (1970) and MacKay (1973) in indicating that nontargets in an attention task undergo semantic analysis. However, a symmetrical facilitative effect of appropriate nontargets was not obtained. One possible reason for the lack of a facilitative effect of appropriate nontargets is that they were often mistaken for targets. Indeed, 6.5% of appropriate nontargets were actually given as responses in lieu of the targets with which they were paired. This target-nontarget confusion factor was successfully reduced in Experiment 2 by changing from binaural presentation of word pairs to dichotic presentation.

EXPERIMENT 2

Method

Experiment 2 was a precise replication of Experiment 1 except that presentation of word pairs was dichotic (one word to each ear) rather than binaural and the number of subjects was 45 rather than 36. The target words in a list alternated randomly between the two ears. Thus, divided attention was still required.

Results and Discussion

The data are summarized in the second row of Table 1. The results deviated from those of Experiment 1 in two ways: The overall rate of target detection was increased from 41% to 54%, and both a facilitative effect of appropriate nontargets and an inhibitory effect of inappropriate nontargets were obtained. Type of nontarget attained significance in an analysis of variance of these data [$F(2,88) = 7.09$, $MSe = .54$]. Newman-Keuls tests confirmed that all three types of nontargets differed from each other in terms of accuracy of target detection. Again, the differences were small in magnitude but highly consistent across subjects.

Experiment 2 extends the findings of Experiment 1 by indicating that the semantic analysis of nontargets can enhance, as well as impede, the detection of targets. The emergence of a facilitative effect of appropriate nontargets was accompanied by a reduction in the rate

Table 1
Percent of Targets Detected in Experiments 1-3 as a Function of Type of Nontarget

Experi- ment	N	Attention Condition	Type of Nontarget				
			Appro- priate		Neutral		Inappro- priate
1	35	Divided, Binaural	42	=	43	>	39
2	45	Divided, Dichotic	57	>	54	>	51
3	27	Divided, Dichotic	67	>	55	>	47
3	27	Focused, Dichotic	74	=	72	=	72

Note—The > and = signs indicate whether or not two percentages were statistically different ($p < .05$).

at which these nontargets were "detected" in lieu of targets: 2.6% in Experiment 2 compared with 6.5% in Experiment 1. As a composite, the data of Experiments 1 and 2 show that the perceptual representations of target stimuli can be affected qualitatively by the nontargets with which they are paired. Experiment 3 was designed to assess the implications of this phenomenon for theories of attention.

EXPERIMENT 3

The third experiment attempted to discriminate empirically between early- and late-selection theories of attention by orthogonally manipulating type of nontarget and precuing of targets. Ninio and Kahneman (1974) examined the effect of precuing on detectability of targets in a dichotic-listening task. In a precuing or focused-attention condition, targets (animal names) were confined to just one ear and subjects were so informed. In a divided-attention condition, targets were randomly distributed between the two ears, and subjects were so informed. Speed and accuracy of target detection were higher in the focused-attention condition than in the divided-attention condition.

Early- and late-selection theories provide different interpretations of the precuing effect. Early-selection theories would argue that precuing enhances the detectability of targets by reducing the perceptual processing of nontargets. Late-selection theories would argue that precuing enhances the selection precision or automaticity of the attention mechanism but has no effect on the amount of perceptual processing of nontargets. An empirical decision between these two classes of theory could be rendered by examining the effect of precuing on the amount of perceptual processing of nontargets.

Amount of perceptual processing of nontargets was measured in terms of the magnitude of the effects of appropriate and inappropriate nontargets. The logic behind this technique was as follows: If the component effects of type of nontarget, like the Lewis (1970) and MacKay (1973) effects, reflect the perceptual processing of nontargets, then variations in the magnitude of these effects may reflect variations in the amount of perceptual processing of nontargets. Within the context of this logic, then, the two classes of attention theory make different predictions. According to early-selection theory, precuing should reduce the effects of appropriate and inappropriate nontargets. According to late-selection theory, precuing should not alter these effects.

Method

A 2 by 3 design was used in which type of nontarget was manipulated under both focused-attention and divided-attention conditions. Each of the latter conditions was administered to a group of 27 students.

The divided-attention condition was, in essence, a replication of Experiment 2. That is, list presentation was dichotic and targets were randomly distributed between the two ears. However, in an effort to increase the effect of type of target, only the

four target categories for which that effect was most pronounced in Experiment 2 were used in Experiment 3. These categories were "body parts," "animals," "edibles," and "clothing." In addition, each list was increased in length from 81 to 324 word pairs. Targets still occurred at the rate of 1 in every nine word pairs, but 27 of the targets in each list were new "filler" targets that were unrelated to the nontargets with which they were paired. The remaining nine targets in each list were the ones used in Experiments 1 and 2 and with respect to which type of nontarget was manipulated.

The lists were identically constructed for the focused-attention condition, except that all targets were presented to the left ear. The left ear was chosen for target presentation so that appropriate and inappropriate nontargets would enter the right ear and be represented predominantly in the left hemisphere. This procedure was expected to increase the opportunity for an effect of type of nontarget in the focused-attention condition and, thus, for the confirmation of late-selection theory. Subjects in each condition were instructed as to the actual distribution of targets between the two ears and were encouraged to distribute their attention accordingly.

Results and Discussion

The results are summarized in the third (divided attention) and fourth (focused attention) rows of Table 1. All three experimental sources of variance attained statistical significance in an analysis of variance of these data: precuing [$F(1,52) = 30.77$, $MSe = 5.20$], type of nontarget [$F(2,52) = 13.89$, $MSe = 1.74$], and their interaction [$F(2,52) = 8.10$, $MSe = 1.89$]. The precuing effect replicates the finding of Ninio and Kahneman (1974): Target-detection accuracy was higher under focused attention than under divided attention. The effect of type of nontarget was the same as that found in Experiment 2: Relative to neutral nontargets, accuracy of target detection was enhanced by appropriate nontargets and inhibited by inappropriate nontargets.

The interaction is of principal interest. A Newman-Keuls test revealed that the effect of type of nontarget was restricted to the divided-attention condition. Moreover, the effect in that condition was larger, in absolute terms, than it was in either of the first two experiments. Evidently, the list-selection procedure succeeded in accentuating the effect of type of nontarget. Nonetheless, this large effect was eliminated by precuing subjects as to the ear of entry of targets.

Despite the fact that the average rate of target detection was well below 100% in the focused-attention condition, one might argue that an effect of type of nontarget in that condition was prevented by a performance ceiling. This possibility was examined by breaking both the focused-attention and divided-attention groups into bottom, middle, and top thirds in terms of the overall rate of target detection. The data for each subgroup are summarized in Table 2. One-way analyses of variance revealed that the effect of type of nontarget was significant in none of the focused-attention subgroups [$F(2,16) = 1.87$, $MSe = 2.57$, for the bottom one-third; $F = 1.26$, $MSe = 3.82$, for the middle one-third; $F = 1.79$, $MSe = .58$, for the top one-third] but was significant in all of the divided-attention subgroups

Table 2
Effect of Type of Nontarget Under Focused and Divided Attention
in Experiment 3 as a Function of Overall Performance
Level of Subjects (Bottom, Middle, and Top)

Performance Level	Type of Nontarget			Mean Level
	Appropriate	Neutral	Inappropriate	
		Divided Attention Condition		
Bottom	57	42	36	45
Middle	68	54	47	56
Top	76	68	58	67
Focused Attention Condition				
Bottom	63	60	59	61
Middle	71	70	74	72
Top	88	86	82	85

Note—Bottom = lower third ($N = 9$) of subjects in terms of overall detection accuracy; middle = middle third; top = upper third.

[$F = 15.51$, $MSe = 1.02$, for the bottom one-third; $F = 6.75$, $MSe = 2.08$, for the middle one-third; $F = 7.12$, $MSe = 1.41$, for the top one-third].

It is important to note in Table 2 that the mean level of target-detection accuracy was higher in the top subgroup of divided-attention subjects than in the bottom subgroup of focused-attention subjects. Nonetheless, the effect of type of nontarget was reliable only in the case of the former subgroup. Hence the important interaction between precuing and type of nontarget cannot be attributed to a mensural ceiling under focused attention. This interaction is consistent with early-selection theory but difficult to reconcile with late-selection theory.

GENERAL DISCUSSION

The present data extend prior findings in two ways. First, they establish further that nontarget stimuli can be processed to a semantic level. As in the Lewis (1970) and MacKay (1973) studies, processing of target stimuli was affected by the semantic properties of nontargets. The present results extend the boundaries of the prior effects of type of nontarget by demonstrating that the semantic properties of nontargets can affect the accuracy, as well as latency, of target detection and can enhance, as well as inhibit, target detection. Thus, nontargets can have a qualitative effect on the perceptual processing of the targets with which they are paired.

The second way in which the present research extends prior findings is by indicating that the amount of semantic processing of nontargets is not invariant. The component effects of type of nontarget disappeared when targets were made more detectable by the precuing manipulation. Similar findings have been obtained in other recent studies. Treisman, Squire, and Green (1974) found that the Lewis (1970) effect dissipates over the course of a dichotic-listening trial. Johnston and Heinz

(1979) found that the Lewis effect is reduced as targets and nontargets are made more discriminable physically. Finally, Underwood (1976) examined a visual version of the Lewis effect and found it to be reduced when subjects are precued as to the spatial position of the target in the stimulus display.³ If the effect of type of nontarget reflects the perceptual processing of nontargets, then the present and other recent data indicate that the amount of this processing is variable. Perceptual processing of nontargets appears to be curtailed, or suppressed, as targets are rendered more detectable as a function of such variables as practice, physical discriminability, and precuing.

Proponents of late-selection theory might argue that the observed variations in the effects of nontargets on responses to targets reflect variations in amount of nonperceptual, rather than perceptual, processing of nontargets. Indeed, variability in the selection precision of the attention mechanism has been explicitly built into the theories of LaBerge (1975) and Shiffrin and Schneider (1977). Under some conditions, the "attention director" has to search through all of the perceptual data for that portion that represents the target. Under other conditions, the attention director "automatically detects" the target representation. Perhaps responses to targets are affected by the semantic (and other) properties of nontargets only when conditions force the attention mechanism to process nontargets in its "controlled search" for targets.

As convincing as this nonperceptual line of reasoning might be, it is inconsistent with the empirical attack that late-selection theorists have launched against early-selection theory. Specifically, the case against early-selection theory has rested primarily on the argument that the findings of Lewis (1970), MacKay (1973), and others reflect the full perceptual processing of nontargets. Late-selection theorists appear to be left with the following choice: Either interpret Lewis-like effects in terms of the perceptual processing of nontargets and admit that this processing is suppressible, or interpret these effects in terms of the nonperceptual processing of nontargets and dismiss their empirical case against early-selection theories. In either event, early-selection theories of attention must be considered to remain a viable alternative to late-selection theories.

REFERENCE NOTE

1. Dawson, M. E., & Schell, A. M. *Electrodermal responses to attended and nonattended significant stimuli*. Paper presented at the meeting of the Society for Psychophysiological Research, Cincinnati, October 1979.

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NOTES

1. The term "late selection" does not accurately describe these recent theories because they allow for the attention director to operate in parallel with, as well as after, perceptual processing of targets and nontargets. However, nontargets are assumed to run their full perceptual course in either case.

2. The level of significance was set at $p < .05$ in all of the statistical analyses referred to in this report.

3. Recent data (e.g., Dawson & Schell, Note 1) also call into question other empirical indicants of the uniformly deep perceptual processing of nontargets (e.g., Corteen & Wood, 1972).

Appendix

Target Categories, Homonyms, and the Nontargets of each Type (Appropriate, Inappropriate, and Neutral) Used in Experiments 1-3

Target Category	Homonymic Target	Type of Nontarget		
		Appropriate	Neutral	Inappropriate
Body Parts	arms	sleeves	plant	weapons
	head	bald	time	leader
	calf	muscular	stapler	cow
	foot	shoe	cigar	inch
	waist	belt	fountain	squander
	chest	hairy	ruler	treasure
	hair	comb	sun	rabbit
	neck	choke	travel	kiss
	nose	kleenex	arrest	understands
Household Items	sink	wash	green	titanic
	hamper	dirty clothes	tortoise	impede
	range	electric	contract	ranch
	bureau	bedroom	sale	federal
	chest	storage	cord	breast
	cabinet	medicine	jacket	government
	counter	kitchen	nest	geiger
	vanity	make-up	degree	selfish
	iron	steam	fish	ore
Child's Toys	train	choo-choo	robin	teach
	blocks	wooden	hem	barricades
	ball	bouncing	smoke	banquet
	scrabble	words	hour	quarrel
	jacks	recess	family	flat tires
	tag	touch	river	price
	marble	round	link	statue
	top	spinning	paper	bottom
	swing	playground	chimney	sway
Animals	duck	quacking	movie	dodge
	ant	crawling	straw	uncle
	swallow	nesting	spoon	drink
	turkey	gobble	ash	india
	fly	buzz	wax	pilot
	badger	caged	violin	harass
	bear	hibernate	luck	naked
	steer	roundup	jam	guide
	deer	antler	amber	sweetheart

Target Category	Homonymic Target	Type of Nontarget		
		Appropriate	Neutral	Inappropriate
Beverages	punch	hawaiian	leech	hit
	tea	iced	slant	golf
	soda	orange	fish	baking
	champagne	bubbly	slant	illinois
	scotch	on rocks	fox	irish
	shake	strawberry	snail	tremble
	squirt	thirst	scale	small fry
	tab	diet	snake	hunter
Clothing	pop	bottle	dog	mom
	slip	lacy	store	slide
	socks	smelly	tuesday	punches
	pants	bell-bottom	lens	dog
	shorts	boxer	bus	fusebox
	suits	men's	carrot	satisfies
	cords	boy's	barber	electric
	coat	sheepskin	dump	paint
Money	hose	snag	grain	garden
	belt	waist	thrush	slug
	quarter	bicentennial	wrestle	football
	franc	paris	wednesday	honest
	check	signed	bone	mate
	pound	british	senate	ounce
	change	pocket	artery	novelty
	cent	ten	column	perfume
Edibles	crown	denmark	viola	headware
	bucks	wallet	celery	bronco
	mark	germany	lift	twain
	rolls	dinner	lazy	royce
	nuts	salted	bridle	crazy
	steak	juicy	path	tent
	ham	smoked	part	actor
	chili	spicy	thursday	freezing
Girls' Names	meat	butcher	grass	introduce
	fudge	homemade	grow	cheat
	shrimp	broiled	joint	pip-squeak
	dessert	sweet	owl	abandon
	jean	harlow	leaf	chromosome
	may	west	shop	month
	carrie	fisher	key	tote
	mary	tyler moore	apple	wed
	carol	burnett	friday	christmas
	ginger	rogers	panama	spice
	florence	nightingale	paper	italy
	rose	kennedy	piano	thorn
	sandy	dennsion	skate	beach

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