

SAMENESS AND REDUNDANCY IN TARGET DETECTION AND TARGET COMPARISON

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Abstract

Searching for targets, people perform better and reap larger redundancy gains when the targets comprise physically different stimuli than when they comprise replicates of the same physical stimulus. Comparing pairs of stimuli on sameness or difference, people are better when sameness is defined by shared physical features than by shared names or shared meaning. This seeming inconsistency of the effect of stimulus sameness and redundancy on behavior is elucidated.

Two popular tasks of cognitive psychology center on the notions of sameness and redundancy, the Redundant Target Design (RTD), and the Same-Different Judgment task (SDJ). In the typical RTD experiment (Townsend and Nozawa, 1995), the stimulus ensemble comprises several items (say, the letters A, B, C and D) some of which are defined as targets (say, A and D), the others as distractors (B and C). On each trial, a pair of letters is presented and the participant's task is to make one response ("Yes") if *at least one* of the letters is a target (AA, DD, DA, AD, AB, BA, AC, CA, DB, BD, DC, or CD), but another response ("No") if none of the letters presented is a target (i.e., both stimuli are distractors, BB, CC, BC, and CB). The impact of redundancy is expressed by the *redundant target effect*: Affirmative target responses are faster to AA, DD, AD, or DA (redundant- or double-targets displays) than to AB, BA, AC, CA, DB, BD, DC, or CD (single-target displays). Note that the redundant targets displays can contain physical replicates of the same letters (AA, DD) or different letters (AD, DA). Surprisingly, the redundant target effect is larger when the redundant targets comprise different letters than when they comprise the same letters (performance and redundancy gains are better with AD or DA than with AA or DD).

In the typical SDJ experiment, the same letters and category assignment (i.e., criteria for sameness and difference) are used. Again, a pair of letters is presented on a trial and the participant's task is to make one response if the two stimuli are the same (e.g., AA, DD, AD or DA) but another response if they are different (e.g., AB, BA, AC, CA, DB, BD, DC or CD). In the SDJ task, performance (latency and errors for "same" responses) is better with replicates of the same letters (AA, DD) than with different letters that share the

category by virtue of the experimenter's assignment (AD, DA). Therefore, to a first approximation, sameness affects behavior differently in the two tasks. There exists a different targets advantage in the RTD task but a same target advantage in the SDJ task. In this article, we elucidate this paradox.

Levels of Processing

This brief introduction already makes clear the need to deconstruct the notion of sameness. It is not the simple self-evident concept that it may appear on a first look. Stimuli can be the same (or different) in at least three aspects. They can be the same *physically*, when a stimulus reappears after a temporal interval or when stimuli are replicas of one another. Stimuli can be the same *nominally* when they share the same name. And, stimuli can be the same *semantically* when they mean the same thing or category or invite the same action. Typically, reproductions of a physical stimulus go by an invariant (i.e., the same) name, and share a semantic meaning. However, physically different stimuli can carry the same name as in A and a. And the nominally identical stimuli A and a are semantically different stimuli when sameness is defined by case. Another interesting exception is the physical stimulus "O," sometimes called "zero," and sometimes called the "o" as in "O my goodness!" Therefore, physically same stimuli can go by different names and mean different things in different contexts.

In many an instance, stimuli that are the same semantically do not share physical features and do not go by the same name. In the aforementioned RTD experiment, A and D were the same semantically (targets triggering the same response), hence redundant stimuli, by virtue of the experimenter's decision to assign them a common response. On the road, a policeman signaling to stop, red traffic lights, or a little girl crossing, all cause you, the driver, to reach for the brakes. They are redundant stimuli because any one of these stimuli alone suffices for eliciting your response. It is this semantic sameness that enables you to reap a redundancy gain when more than one of the stimuli are present (you reach for the brakes faster with policeman signaling and the little girl crossing than you do with either stimulus appearing alone).

As we recounted in the outset, the criterion selected for sameness and difference (by nature or by an experimenter) affects the behavioral outcome in a systematic fashion. Surprisingly, the effect appears to be different in the RTD experiment and the SDJ experiment. This difference might tap different cognitive heuristics.

Using variants of the SDJ task, Posner (1978, see also, Posner and Snyder, 1975) proposed a general hierarchy of processing based on the three levels of sameness or difference that we discussed (physical, nominal, or semantic). In Posner's view, various tasks and criteria tap onto one (or more) of these levels of processing. Perceptual tasks are fastest, semantic tasks are slowest, and nominal ones are intermediate. In substantive terms, the visual system first analyses the physical features of the presented stimulus, constructing a visual code for comparison. This visual code then is linked to a name. This name in turn serves in semantic tasks of categorization. This theory implies a temporal hierarchy from physical to nominal to semantic sameness (or difference). We next examine the pertinent results in the two tasks associated with sameness and redundancy.

Levels of Sameness in the RTD Task

What does sameness mean in an RTD environment? Do stimuli need to be physical replicates of one another in order to be redundant? Does nominal or semantic sameness suffice to produce the redundant targets effect? How does the magnitude of the redundant targets effect depend on the composition of the targets? In general, to what extent or to what level do stimuli have to be the same in order to be redundant? This critical issue has not been pursued in the RTD literature – with a single notable exception. Grice and Reed (1992) defined as targets the letters A and a. Obviously, these targets share names but differ physically. Grice and Reed compared performance on double-target trials comprising letters Aa with that on double target trials comprising AA or aa in which the targets were physical reproductions of one another. They found redundancy gains for both types of double-targets. Notably, the gains were considerably larger for Aa than for either AA or aa.

In another experiment, Grice and Reed (1992) used targets that shared neither physical nor nominal features. The capital letters A and D were defined as targets. Redundancy gains were obtained both for AD or DA and for AA or DD as redundant targets. Again, the redundant target effect was larger for the different targets displays (AD, DA) than for the same target displays (AA, DD). Subsequently, Mordkoff and Miller (1993) argued that if participants respond much faster to one target than to the other, then Grice and Reed's (1992) results obtain. Mordkoff and Miller (1993) replicated the second experiment by Grice and Reed, controlling for target preferences and inter-stimulus contingencies. Notably, Mordkoff and Miller still found performance on different-targets trials to be at least as good as performance on identical targets trials.

Therefore, in the RTD experiment physically and nominally different targets tend to yield better performance than physically same targets.

Levels of Sameness in the SDJ Task

The issue of levels of sameness has received considerable attention in the SDJ literature. Early results reported by Posner and Mitchel (1967) proved to be general. They presented pairs of letters in an SDJ task under three different criteria for sameness: physical, nominal, and semantic. Participants were faster to classify pairs of letters as "same" on the basis of physical identity (AA) than on the basis of nominal identity (Aa). It took participants even longer to classify letters on the basis of semantic category membership (AE are the same because both are vowels). A summary of Posner and Mitchell's data is presented in Figure 1. Observe the effect of response criterion: RTs for physical sameness were 74 milliseconds faster than for nominal sameness, which in turn were 76 milliseconds faster than those for semantic sameness. That is, reaction times (RTs) for a criterion at a given level of processing were faster by 75 milliseconds on average than those for a criterion at the next level of processing.

In the SDJ task, therefore, physically identical stimuli tend to yield better performance than nominally or semantically same stimuli.

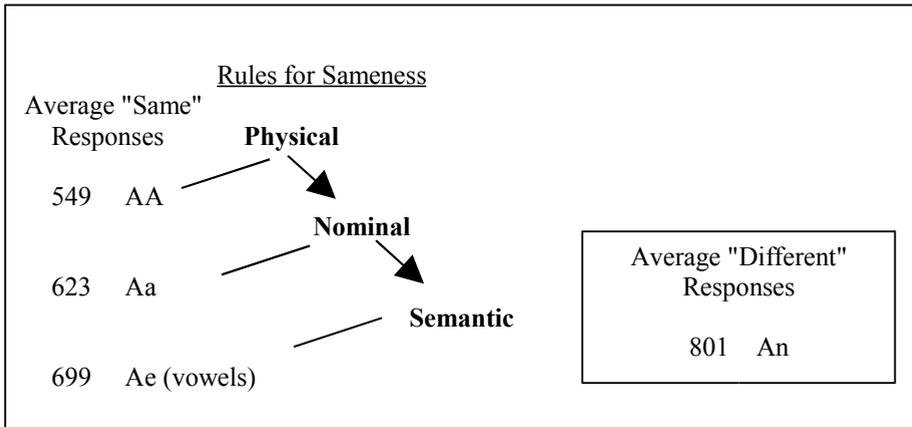


Figure 1: Illustration of the effect of the definition of sameness on performance. Mean RTs (milliseconds) for letter pairs in a SDJ experiment. [Adapted from Posner and Mitchel, 1967].

The Paradox

Sameness and redundancy are like Tweedledum and Tweedledee. Each implies the other to the extent that they probably refer to a single concept. Sameness implies redundancy reflected in the common caveat against repeating the same stimulus twice or more. And, redundancy, in turn, implies sameness. In the dictionary (The American Heritage Dictionary, 1985, p. 1038), redundancy is defined as "unnecessary repetition." Obviously, you can repeat only the same action or stimulus. In Information Theory, too, redundancy is conceived as "repeated information" (Miller, 1953, p. 9), implying sameness. By definition, different information cannot be redundant. This much granted, stimuli need not be physical replicates of each other in order to reap redundancy gains in behavior. Given the close association between sameness and redundancy, it is puzzling that two popular tests of the effect of each stimuli on behavior yield seemingly inconsistent results.

The effect of stimulus sameness can be generally assessed through two separate paths. RTD exemplifies the *functional* or behavioral approach: All stimuli producing a given response are considered "same" by virtue of this fact. In other words, response evocation defines sameness or redundancy. The SDJ is predicated on another, *psychophysical* approach. Stimuli are the same if they share the same properties and are perceived correctly as replicates. Sameness is thus defined directly by the judgments of observers.

Why does physical sameness enhance performance in the SDJ task, but does not enhance performance in the RTD task? Conversely, why do physically (and nominally) different stimuli lead to large gains in the RTD task, but are less well perceived and processed in the SDJ task? When judging stimuli directly on sameness, physical features seem decisive. However, when the stimuli are presented for action, common meaning, and not common physical appearance is decisive. Resolving the various effects of stimulus sameness and redundancy on behavior gives sustenance.

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