THE SAME-DIFFERENT TASK: IMPLICATIONS OF REDUNDANT ATTRIBUTES ON THE DECISION-MAKING PROCESS

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Abstract

Since its discovery by Bamber (1969), there have been many attempts to explain the *fast-same phenomenon*. However, no theory has provided an acceptable explanation of its mechanism. In the current study, the redundant attribute of color was added to the stimuli in the Same-Different task, similarly seen in Harding (2018, 2013). Twenty-three undergraduate students from Grenfell Campus (MUN) voluntarily participated in this study. Each trial included the presentation of two sequential stimuli (i.e. strings of letters varying from 1 to 4 characters in length). The colors of the two stimuli were either matching (Red/Red or Blue/Blue) or mismatching (Red/Blue or Blue/Red). Participants were asked to indicate whether the stimuli were the 'Same' or 'Different' solely based on the identity of the letters in each string (e.g. 'Same': J vs. J; and 'Different': J vs. B); colors were to be ignored. Graphical analyses indicated that the *fast-same phenomenon* did occur in the data. A graphical analysis also revealed that the participants' response times (ms) for mismatching color trials were higher than those of the matching color trials for all 'Same' conditions; however, a 4×2 between-groups ANOVA revealed this difference was not significant ($p = .418$). Although not significant, the difference between mismatching and matching color conditions could be a result of how hard the decision-making mechanisms had to work; an increase in cognitive load could have led to this increase in response time.

The Same-Different Task: Implications of Redundant Attributes on the Decision-Making Process

How we interpret and identify two stimuli as the 'Same' or 'Different' has been a long-standing debate in cognitive science. Several models have been proposed, all attempting to explain this decision-making process, with many—almost all of them— failing to fully explain the underlying mechanisms. In particular, researchers have yet to provide a satisfactory explanation for the incidence where people tend to make 'Same' decisions faster than they can make 'Different' decisions for stimuli of identical complexity; a trend known as the *fast-same phenomenon* (first found in Bamber, 1972; see Farell, 1985 for a review of the phenomenon). The reality of the *fast-same phenomenon* is counter-intuitive to the fundamental logic of most cognitive models: 'Same' decisions rely on analyzing *all* elements of a given stimulus and comparing it to *all* the elements of another stimulus (an exhaustive stopping-rule); whereas just one difference between the two stimuli would allow for a 'Different' decision to be made (a self-terminating stopping-rule). Thus, it would be logical to predict that 'Same' judgments would take longer to produce, as is predicted by all models with a self-terminating stopping rule (Bamber, 1969).

Egeth (1966) exhibits some of the earliest work with the Same-Different task, yet the speed discrepancy between both decisions was not formally explored until Bamber's (1969) seminal work. Bamber (1969), offered a dual process approach in which an analytical model (labeled the Serial Processor) processes both 'Same' and 'Different' providing a signal (i.e. decision) according to the serial self-terminating model of processing, while a holistic model (labeled the Identity Reporter) detects only matching stimuli. The Identity Reporter seemingly emits a signal only if stimuli are the 'Same'; therefore, no signal would be emitted if the stimuli are not matching. Bamber (1969) suggested that the Identity Reporter is considerably faster than the Serial Processor, hence the signal for matching stimuli (i.e. 'Same') would be initiated prior to—and more quickly than—the completion of the Serial Processor. Thus, a 'Same' response could be made quicker given that 'Different' responses solely rely on self-terminating processing.

Although Bamber's (1969) model was rooted in intuitive and simplistic logic, empirical data do not coincide with his models. Furthermore, it is uncertain as to whether or not the Identity Reporter's failure to emit a signal indirectly indicates a 'Different' response (i.e. this would only be the case if the brain interprets the consistency of stimuli solely as a dichotomy; 'Same' or 'Different'). In an extension of his original task, Bamber (1972) studied the impact of redundancy where in one instance, stimuli could be physically matching (and thus exhibiting redundancy) and in another, they were physically mismatching (no available redundancy). In the physically mismatching condition, it is hypothesized that the Identity Reporter could not operate and thus forces the Serial Processor to trigger both decisions. This should, in turn, make for slow 'Same' response times given that the comparison would force the use of the serial exhaustive model of processing; however, Bamber (1972) found the opposite – 'Same' responses were still faster than the slowest 'Different' condition (albeit slightly attenuated).

Krueger (1978) offered another theory regarding the occurrence of the *fast-same phenomenon* in the Same-Different task; the *Noisy Operator model*. He suggested that the decision process for participants involves the rechecking of all features in the second stimulus, specifically when there appears to be a difference between the two stimuli. As the model predicts, noisy perception influences the participants' ability to differentiate between stimuli as 'Same' of 'Different' (e.g. matching features could be misinterpreted as mismatching, but the opposite is rarely true). Kruger's suggestion of sequential scanning of each feature of the stimuli to identify the specific location of the difference provides reasoning as to why ‘Same’ decisions appear to be faster than ‘Different’ decisions. Essentially, the added process of rechecking and locating the position of the difference (exclusively in ‘Different’ trials) leads participants to make ‘Same’ decisions faster than ‘Different’ decisions. One issue with this approach is that the added influence of noise (which is suggested to prompt the need for rechecking) makes this a convoluted model and provides the incentive for further research into the *fast-same phenomenon*.

Additional research of the phenomenon has focused on the possible effects of priming. Proctor (1981) found that repetition of a stimulus leads to faster recognition for ‘Same’ judgments: since the stimulus has already been encoded from its first presentation, it is quickly analyzed on the second presentation, resulting in a faster ‘Same’ response. The latter proposition of residual activation has been formally explored in other priming models such as the nROUSE model (Huber, 2008) in which residual activation present in the encoding pathways makes for speeded responses. In contrast, ‘Different’ responses never benefit from priming effects due to dissimilar stimuli being encoded on each stimulus presentation (i.e. there are new, unseen features present on the second stimulus that were not present on the first stimulus). Although seen to be parsimonious, the idea that priming alone could account for the *fast-same phenomenon* is contested by Proctor’s contemporaries and it faults to comment on the decision-making strategy (Harding, 2018).

While other models have attempted to predict the *fast-same phenomenon*, the current study focuses primarily on the coactivation model of information processing. This model suggests that either a ‘Same’ or ‘Different’ judgment will be made by attaining sufficient redundant information— enough to be certain of the decision—through any integration method (Miller, 1982). For example, in a task where the concepts of red and squareness are targets, the presentation of a red-square stimulus would yield faster detection speeds than a red or square stimulus alone. Since the presence of redundant information has shown to decrease response times (Miller, 1982), we can theoretically add a redundant component to the Same-Different task and attempt to explain the *fast-same phenomenon* via the coactivation model. This can be done via the use of colours as was introduced in Miller's (1978, 1982) proposition of the coactive model in a task of similar nature to the Same-Different task, known as the Redundant-Target-Attribute task. In the Same-Different task, when two stimuli and the colors of these stimuli match, residual activation could potentially be induced, likely with the occurrence of priming (Harding, 2018). The residual information left behind by the first occurrence of the stimulus allows for the faster 'Same' judgement when presented with the identical stimulus a second time. However, when colors mismatch, we force a more analytical approach to the decision-making process, one that does not benefit from coactivation yet could have remnants from the priming effects; there is little residual information to allow for a faster decision-making process.

While the coactivation model is often characterised by an increase in processing speed, one way in which the coactivation model has yet to be considered is through the concept of cognitive load. Priming effects that likely occur when judging two identical stimuli as the 'Same' may lead to a lesser cognitive load (i.e. fewer 'Different' pieces of information held in working memory) than when judging two stimuli that are 'Different'; the stimulus could be fast-tracked through the processing hierarchy, therefore requiring fewer processing resources. Hence, it is suggested that the inability to prime the stimulus (specific to 'Different' trials) may lead to a greater cognitive load and subsequently a longer decision-making response time.

It is of note that the addition of color as a redundant element of the stimuli should not change the underlying decision-making mechanisms, only how hard those mechanisms work.

Theoretically, adding matching color to ‘Same’ trials would decrease the time it takes to make an accurate decision. That is, there would be more information for priming effects which ultimately could lead to a lesser cognitive load when analyzing the second stimulus. This would likely result in a decrease in the cognitive resources required to make a correct decision, leading to a decrease in response time. Furthermore, adding mismatching color to ‘Different’ trials would increase the amount of information in working memory (i.e. a larger cognitive load) since each stimulus would have its own color characteristic. This would result in an increase in the cognitive resources necessary to make the correct decision. That is, more cognitive resources would be required to assess the relevant information and to further compare the stimuli, leading to an increase in response time. Likewise, if mismatching color was added to ‘Same’ trials, we would expect to see response times slightly higher than that of ‘Same’ trials with matching color. That is, additional information that does not contribute to priming effects would increase the cognitive load, making the mechanisms of the decision-making process work harder. We expect to see that the response times for matching color ‘Same’ trials will be lower than the response times for mismatching color ‘Same’ trials due to the occurrence of priming effects and the impact on cognitive load.

Additionally, we expect to see quicker response times as the number of differences between stimuli increases. That is, an increase in the number of differences (i.e. a decrease in the number of ‘Same’ letters between the first and second stimuli) would logically lead to a higher probability that the differences will be identified and located more quickly than if there was only one difference (e.g. in a four-letter string, it is likely to see a quicker response time when there are four differences than when there is one difference). We also anticipate slower response times as the length of the string increases. That is, an increase in the number of letters is anticipated to result in an increase in both the amount of encoding that must be done and in the amount of information held in working memory, thereby an increase in the length of time it takes to encode and respond. Since the response times that will be measured will include both the encoding and responding process, it is only logical to assume that an increase in the time it takes to encode would lead to an increase in the overall response time. It is also worth noting that for most trials, we expect to see that accuracy rates vary only slightly, a frequent trend seen in much of the research with the Same-Different task.

Method

Participants

Twenty-three undergraduate students from Memorial University of Newfoundland's Grenfell Campus voluntarily participated in this study. This is more than five times the participants than Bamber's (1969) original work (4 participants doing 276 trials, excluding non-analyzed practice trials), which satisfies and surpasses the statistical power necessary to replicate the appropriate Same-Different task results. All participants either had normal or corrected vision and were fluent in English. Additionally, as the study necessitates the processing of matching/mismatching colours, individuals who were unable to discriminate between red and blue were not considered for the task. Participants gave written and verbal consent to participate in the task and compensation was provided to students who were part of the *Grenfell Campus Participant Pool*. Compensation was in the form of bonus marks with a value of 2%.

Materials

The experiment was comprised of the programmed E-Prime version 2.0.8.356 (Psychology Software Tools, 2012), where stimuli were displayed on a calibrated CRT monitor having a resolution of 1024 × 768 pixels, a screen refresh rate of 85 Hz, and was calibrated to ensure luminance and RGB standard across participants. Participants were seated approximately 50 cm from the monitor with a computer keyboard placed directly in front of them (the keyboard is used to record the participants' decisions and can be adjusted to ensure a comfortable setting).

Stimuli

Stimuli were randomly generated from a set of 12 uppercase consonants (B, C, D, F, J, K, L, N, S, T, V, Z) to match Bamber's (1969) original study and were placed at a visual angle of 10° centered on the screen; the first stimulus was shown 4° above center and the second stimulus was shown 4° below center. Stimuli were presented as red or blue on a black background. Each stimulus varied in length (L) from one to four letters. Two stimuli were considered the 'Same' when all the letters in two sequential same-length strings shared the same identity and were in the same order/position (e.g. BCD and BCD; 0D). Two stimuli were considered 'Different' when a varied number of different letters comprised the second stimulus, in reference to the first stimulus (e.g. JCD and JCB; the number of differences within a string varied between 1 and L for nomenclature of *d*D*l*L). Additionally, for 'Different' stimuli the matching letters were in the same position and the strings were always of the same length.

The colors of the stimuli in each trial either matched or mismatched. The occurrence of each possibility was completely counterbalanced. One-half of the trials exhibited matching colours: either red/red or blue/blue (an equal number of trials for both). The other half of the trials exhibited mismatching colours: either red/blue or blue/red (an equal number of trials for both).

Procedure

Interested participants were first given a brief overview of the task requirements and exclusion criteria through email, followed by instructions to go to the testing area located on

Grenfell Campus where participation was done individually. Prior to the task, participants were provided with an informed consent form; only after verbal and written consent was given did anyone begin the research task.

The participants were each instructed that pressing <Control/Enter> on the keyboard would record their decisions and that the on-screen instructions would tell them which decision is associated with which key. It was reiterated that the <Control> key to be used was on the far-left side of the keyboard and the < Enter> key was on the far right of the keyboard (on the numeric pad). The associated decision to each key was counterbalanced based on participant number in order to ensure that there the least amount of dominant hand bias as possible.

At the beginning of each trial, participants were presented with a blank black screen for 500 milliseconds (ms). Following this, they were presented with the first stimulus for 400ms allowing the participant to encode the stimulus. Following the first stimulus was an inter-stimulus interval (another blank black screen) of 400 ms. The participants were then presented with the second stimulus for 5000 ms. During that presentation, participants' judgments of either 'Same' of 'Different' were made. The trial ended with 500 ms for feedback on the participants' decision, only if there was an error or a non-response (i.e. participants were notified if they made an incorrect response). A blank black screen was shown for correct responses, in order to not divert their attention for the next trial. After the participant responded (or did not respond) they were presented with another trial. Figure 1 shows the timeline of a typical trial.

[INSERT FIGURE 1 HERE]

Experimental Design

One session of 768 trials was composed of four blocks, each containing 192 trials. After each block, participants had the option to take a short break. On half of these trials, the colours between stimuli matched and on the other half they mismatched; participants were instructed to base their 'Same' or 'Different' decision solely on the identity of the letters presented and to ignore the colour of the stimuli. Table 1 summarizes these conditions (string length × number of differences) with the number of trials in each condition for a total of 384 trials in each of the two-colour conditions. Strings of all lengths had an equiprobable chance of occurrence, with the number of differences within each string varying randomly between 0 and L. Moreover, all trials were presented in a random order and completion of the 768 trials marked the end of the tasks for the participants. Each participant was provided with a debriefing form and thanked for their participation.

[INSERT TABLE 1 HERE]

Results

Data was collected from 23 participants and analyzed using SPSS. Each participant completed 768 trials, for a total of 17,664 trials. There were 17,047 correct responses, equivalent to a 96.51% success rate. Prior to running analyses on the dataset, possible outliers were removed. Outlier criteria included any responses that took longer than 2500 ms or were quicker than 200 ms. The maximum response time (RT) of 2500 ms was chosen because above this point, we are not measuring fast RT and the decision-making process was likely given too much time (i.e. not a depiction of a primary automatic response). The accepted value for mean choice response time for college-age individuals has been about 190 ms (Welford, 1980). Hence, choosing a minimum RT of 200 ms allows us to be more confident that each response consisted of sufficient encoding. With responses lower than the 190-200 ms range, we are likely no longer within the biological limits of encoding and answering (encoding and motor time). Given that the nature of the task for participants was to respond as quickly as possible, trials with very slow response times and trials with very fast response times were removed. There was a total of 84 outliers removed. Of these outliers, all had response times above 2500 ms; there were zero outliers with response times below 200 ms. There were an additional 617 incorrect responses (including 3 non-responses and 8 of the responses above 2500 ms) removed from the dataset. The sum of the outliers, incorrect responses, and non-responses accumulated a total of 693 errors. Therefore, a total of 16,971 validated trials were analyzed. Of the total trials analyzed, the slowest response time was 2478 ms and the fastest response time was 265 ms.

To determine that we could aggregate the data of both matching color (Red/Red and Blue/Blue), a 14×2 between-factors ANOVA of matching color conditions was conducted. It was revealed that there was no significant difference between response times of the color matching conditions, $F(1, 642) = 0.01$, $p = .941$. This meant that both color matching conditions could be combined. Moreover, to determine that we could aggregate the data of both mismatching conditions (Red/Blue and Blue/Red), a 14×2 between-factors ANOVA of mismatching color was conducted. Similarly, it was revealed that there was no significant difference between response times of the color mismatching conditions, $F(1, 642) = 1.004$, $p = .950$. This meant that both color mismatching conditions could be combined as well. These analyses showed that the data may be divided according to matching color and mismatching color conditions.

The dataset was divided by matching color trials and mismatching color trials. Each of these conditions was also divided by both the number of letters in the trial stimuli and the number of differences between the first stimulus and second stimulus in each trial. This totaled to 14 trial conditions for matching color and 14 trial conditions for mismatching color. Again, Table 1 shows the organization of trials per condition, when stimuli colors were matching and mismatching.

Table 2 shows the descriptive statistics of participants' response times (ms) for each of the 14 possible trial conditions when color was both matching and mismatching. As shown in Table 2, the highest mean response time (i.e. the slowest response time) was found for 1D4L trials. This was the case for both matching color and mismatching color conditions. Similarly, the lowest mean response time (i.e. the fastest response time) was found for 0D1L trials. This was again the case for both matching color and mismatching color conditions.

[INSERT TABLE 2 HERE]

Figure 2a is a graphic representation of the mean response times (ms) for each of the possible stimuli lengths as well as the possible number of differences, when the colors of the first and second stimuli were matching. This figure illustrates that the quickest average response times (ms) from individuals, when stimuli were presented with matching colors, occurred when the stimuli were the 'Same' (i.e. the identity of the first and second stimuli were identical) for all string lengths except string lengths of four. Notably, 4D4L trials were actually quicker than 0D4L trials. Moreover, Figure 2a illustrates that trials with 1 difference between stimuli were slower for all string lengths except for 2D2L.

Figure 2b graphically represents the mean response times (ms) for each of the possible stimuli lengths as well as the possible number of differences, when the colors of the first and second stimuli per trial were mismatching. Similarly, to the conditions in Figure 2a, when the identities of the stimuli were the 'Same' response times (ms) were faster than when the identities of the stimuli were 'Different', except with the 4D4L trials.

[INSERT FIGURES 2a & 2b HERE]

Table 3 shows the descriptive statistics of participants' mean response accuracies for each of the 14 possible trial conditions when color was both matching and mismatching. As shown in the upper half of Table 3, the highest mean response accuracy for matching color stimuli was found for 2D3L trials (*M* = 0.989 *SD* = 0.104). However, of the 14 conditions for matching color, 13 of them had accuracies at or above 94%. The lowest mean response accuracy for matching color stimuli was found for 1D4L trials (*M* = 0.855, *SD* = 0.353). As seen in the lower half of Table 3, the highest mean response accuracy for mismatching color stimuli was found for 3D4L trials (*M* = 0.978, *SD* = 0.146). Of the 14 conditions for mismatching color, 13 of them had accuracies at or above 95.1%. Similar to the matching color condition, the lowest mean response accuracy for mismatching color stimuli was found for 1D4L trials (*M* = 0.812, *SD* = 0.392).

[INSERT TABLE 3 HERE]

Figure 2c and Figure 2d illustrate mean response accuracies for each of the possible stimuli lengths as well as the possible number of differences, when colors were both matching (c) and mismatching (d), respectively. As you can see in both figures—matching and mismatching conditions—accuracy declined dramatically when the stimuli were 1D4L. This means that participants were making incorrect responses most frequently for the 1D4L condition.

[INSERT FIGURES 2c & 2d HERE]

A 4×2 between-groups ANOVA was conducted to compare each of the four ‘Same’ conditions (trials consisting of stimuli with 0 differences) between matching and mismatching color conditions. It was revealed that there was no significant difference in the response times (ms) between each of the four conditions of the matching and mismatching color conditions, $F(1, 182) = 0.66$, $p = .418$. Therefore, stimuli length did not seem to significantly influence the response times (ms) of participants between color matching and mismatching conditions. Figure 3 illustrates this relationship between matching and mismatching color conditions.

A 10×2 between-groups ANOVA was conducted to compare each of the 10 'Different' conditions (trials consisting of stimuli with 1 to L differences) between matching and mismatching color conditions. It was revealed that there was no significant difference in the response times (ms) between each of the 10 conditions of the matching and mismatching color conditions, $F(1, 458) = 0.04$, $p = .849$. Therefore, stimuli length and the number of differences did not seem to significantly influence the response times (ms) of participants between color matching and mismatching conditions.

Discussion

As previously discussed, the ability (or inability) to prime a stimulus could lead to a change in one's cognitive load—and subsequently a change in response time—within the context of a Same-Different task. Specifically, 'Different' trials inherently lead to the inability to prime a stimulus which leads to an increase in cognitive load, and therefore an increase in response time. Conversely, 'Same' trials benefit from priming effects, leading to a decrease in cognitive load and a decrease in response time. Together, these two relationships demonstrate and predict the *fast-same phenomenon*.

In line with the expectation of the *fast-same phenomenon,* and consistent with past research (Bamber, 1972; Harding, 2013; 2018), response times of 'Same' trials were, in fact, quicker than the response times of the slowest 'Different' trials, for both matching and mismatching color conditions. Therefore, the *fast-same phenomenon* was demonstrated, and it is likely that priming effects and residual information have an impact on the mechanisms of decision-making. How, and why, priming and residual information affects the response times of decision-making is unclear. However, exploring the coactivation model (Harding, 2018) through cognitive load seems to predict many of the findings: an increase (or decrease) in the amount of information to encode in an individual's working memory can increase (or decrease) the time it takes the individual to encode and compare information. For example, specific to 'Same' trials, the residual information from the first stimulus could allow for quicker encoding of the second stimulus as a result of fewer cognitive resources required for the second encoding. Furthermore, with 'Different' trials, the second stimulus is comprised of whole new information needed to be encoded, requiring more cognitive resources, thus causing a slower response time.

The introduction of color as a redundant attribute in both 'Same' and 'Different' trials should inherently increase an individual's cognitive load during the Same-Different task, leading to an increase in response time (although, 'Different' trials wouldn't benefit from priming effects or residual information). That is, each of four conditions would differ in respect to the cognitive load required to make the comparison: 'Same' trials with matching color would demonstrate a lower cognitive load than 'Same' trials with mismatching color, while 'Different' trials with matching color would also demonstrate a lower cognitive load than 'Different' trials with mismatching color. Therefore, the mismatching colors would lead to an increase in an individual's cognitive load and an increase in response time, as compared to matching colors. However, given that 'Different' trials would not largely benefit from priming effects or residual information, a change in cognitive load alone would not likely have a large enough impact to see a difference between matching and mismatching color conditions in 'Different' trials. Moreover, 'Same' trials potentially exhibit quicker reaction times not only because of possible priming effects of letter and color, but also because of the addition of relevant target attributes (Egeth, 1966). An increase in the number of similarities between the stimuli seems to result in quicker response times. Furthermore, as there is an redundant attribute accompanied with 'Same' stimuli (same letters with different colors), it demonstrates slightly fewer similarities between the stimuli, which results in the slightly slower response time. These relationships were demonstrated by the results, however, differences between the matching color and mismatching color groups were not significant in the ‘Same’ trials.

The relationship between matching and mismatching color found in the current study is both consistent and contradictory with past research. Similar to the current study, Harding (2013) demonstrated that color as a redundant attribute did not have much impact on ‘Different’ trials. Moreover, the current study found a consistent difference—despite not being significant—between matching and mismatching color trials in all the ‘Same’ conditions: mismatching trials consistently demonstrated slower response times between all conditions. This finding, however, was not fully supported in Harding (2013); he found that a difference between matching color and mismatching color ‘Same’ trials only existed on conditions with string lengths of two and three.

Consistent with the logic that an increase in cognitive load would lead to an increase in response time, it was anticipated that an increase in the string length would lead to an increase in the response times. The results show some support for this relationship and were mostly consistent with past research by Bamber (1972), however there is a key difference between the current study and previous research by Harding (2013). That is, in the mismatching ‘Same’ condition results obtained by Harding (2013), there were ceiling effects and slope attenuation in the response times. Specifically, his results demonstrated that string lengths of two, three, and four had similar response times in the ‘Same’ trials. These ceiling effects were not demonstrated in the current study. This difference could have been caused by many factors, including possible variances between the participants involved in both studies. The research by Harding (2013) consisted of 15 undergraduate students while the current study consisted of 23 undergraduate students. Additionally, given the lack of demographic information on participants from both Harding (2013) and the current study, it is possible that the difference between the results occurred because of the unknown variance between the two groups of participants. Overall, the results of the current study provided some evidence for a positive relationship between string length and response time. However, the explanation is not fully sufficient due to the trend in response time not fitting the model completely.

Given the simplicity of the Same-Different task used in the current study, relatively consistent accuracy rates for participants' responses across conditions were expected to be observed. The results of the current study did show this consistent trend for the majority of conditions. However, for both matching and mismatching color conditions, the accuracy rates for the 1D4L condition were dramatically lower than all other conditions. This could be explained by participants' method(s) for examining and comparing stimuli. For example, if the participant saw three identical letters between the stimuli, they may have automatically assumed that the stimuli were the same. These results for response accuracy are not surprising given that much research with the Same-Different task has consistently demonstrated high accuracies in almost all conditions; with the 1D4L condition consistently showing the lowest accuracy (Bamber, 1972; Harding, 2013).

Attempting to explain the occurrence of the *fast-same phenomenon* in the Same-Different task by exploring the coactivation model through cognitive load overcomes the highly theoretical nature of Bamber's (1972) dual-process theory and the convolution associated with Krueger's (1978) *Noisy Operator Model*. The current approach is influenced by the ideology of priming and residual information (Proctor, 1981; Harding, 2018) as well as the coactivation approach

(Miller, 1982). Despite the logical nature of the current theoretical approach, it does not go without its shortcomings; the same is said for the mechanics of the study.

First, it is necessary to point out that, although the results of the current study provide some support for the positive relationship of cognitive load and response time, the data does not always follow this trend: there are incidences where a higher string length (assumed to cause an increase in cognitive load) show a decrease in response time. Therefore, this alone suggests that cognitive load alone does not provide a holistic explanation of the *fast-same phenomenon*.

Secondly, there is a chance that the introduction of color as a redundant attribute of the Same-Different task stimuli may also introduce additional cognitive functions which do not relate to the task at hand. For example, although color is not a factor of the decision in this task, it is likely that the brain still interprets and compares these attributes of the stimuli. The brain may not only do this by comparing visual stimuli but may also translate the visual color into its associated word or meaning (e.g. thinking of the word 'Red' when you see the color Red). If this is the case, there is an unnecessary use of cognitive resources which would likely artificially increase the response times being researched. Effects of this kind could likely be reduced in future research where the stimuli could consist of lower case and upper-case letters, making the 'Same' or 'Different' decision based solely on the identity of the letters and not the case form of the letter. In this form of the Same-Different task, you would not have any unnecessary forms of internal semantic cognitions that could potentially increase (albeit artificially) the response times.

Explaining the *fast-same phenomenon* via the coactivation model and cognitive load provides another perspective of a currently unexplained phenomenon. Research in the area (such as the current study) is so important, particularly replication research. That is, further understanding of the underlying mechanisms that comprise the decision-making process would allow for the development and invention of cognitive tasks and possibly cognitive-based therapeutic techniques. Moreover, meaningful findings become stronger and more robust as the amount of supporting evidence increases, thus replication of findings is key to the development of the associated theory. The results of the current study demonstrated many similarities with past research by Bamber (1972) and Harding (2013), while also exhibiting some rather unique findings, specifically the occurrence of mismatching color trials demonstrating slower response times than matching color trials in the ‘Same’ conditions; a result that was not surprising given the basis of the positive relationship anticipated between cognitive load and response time. This theoretical approach to viewing the *fast-same phenomenon* may prompt further research into the field of cognition and the study of the human brain. Specifically, replication of this study with the use of stimuli other than letters or with the addition of brain imaging (e.g. EEG) would elevate this research to new heights.

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Tables and Figures

Table 1

Number of trials (for each participant) per condition as a function of stimuli length and number of differences, for both color matching and color mismatching conditions.

Stimuli Length	**Same**	**Different**			
	0D	**1D**	**2D**	**3D**	**4D**
1	48	48			
2	48	24	24		
3	48	16	16	16	
4	48	12	12	12	12

Note: the letter D refers to the number of differences within the stimulus.

Table 2

Descriptive statistics of response time (ms) for the 14 possible trial conditions, as a function of stimuli length and number of differences, for both matching color trials and mismatching color trials.

Stimuli Length	Same	Different			
	0D	1D	2D	3D	4D
		Matching			
1					
M	560.31	646.78			
SD	252.80	289.43			
n	1068	1072			
2					
M	574.53	655.46	655.85		
SD	260.22	270.22	313.86		
n	1067	536	542		
3					
M	598.55	684.63	623.22	613.56	
SD	267.66	256.63	244.53	256.57	
n	1054	345	363	362	
4					
M	608.13	716.71	669.31	621.31	601.60
SD	244.52	301.45	273.84	253.89	219.30
n	1061	236	265	261	270
		Mismatching			
1					
M	576.01	649.96			
SD	269.49	314.43			
n	1073	1073			
2					
M	587.79	673.77	622.95		
SD	243.78	291.69	278.13		
n	1058	535	530		
3					
M	610.68	700.58	632.34	610.93	
SD	268.95	257.98	268.90	227.45	
n	1069	347	356	356	
4					
M	627.93	763.22	646.74	632.69	578.65
SD	236.55	312.96	257.66	251.53	186.01
n	1052	224	261	269	266

Note: the letter D refers to the number of differences within the stimulus.

Table 3

Descriptive statistics of response accuracy (%) for the 14 possible trial conditions, as a function of stimuli length and number of differences, for both matching color trials and mismatching color trials.

Stimuli Length	Same	Different			
	0D	1D	2D	3D	4D
Matching					
1					
M (%)	97.1	98.0			
SD (%)	16.8	14.0			
n	1104	1104			
2					
M (%)	96.8	97.5	98.7		
SD (%)	17.5	15.7	11.2		
n	1104	552	552		
3					
M (%)	95.7	94.0	98.9	98.4	
SD (%)	20.2	23.7	10.4	12.7	
n	1104	368	368	368	
4					
M (%)	96.4	85.5	96.0	94.9	98.2
SD (%)	18.7	35.3	19.6	22.0	13.4
n	1104	276	276	276	276
Mismatching					
1					
M (%)	97.5	97.4			
SD (%)	15.7	16.0			
n	1104	1104			
2					
M (%)	96.4	97.8	97.5		
SD (%)	18.7	14.6	15.7		
n	1104	552	552		
3					
M (%)	97.0	95.1	97.6	97.0	
SD (%)	17.0	21.6	15.5	17.1	
n	1104	368	368	368	
4					
M (%)	95.9	81.2	95.3	97.8	97.1
SD (%)	19.8	39.2	21.2	14.6	16.8
n	1104	276	276	276	276

Note: the letter D refers to the number of differences within the stimulus.

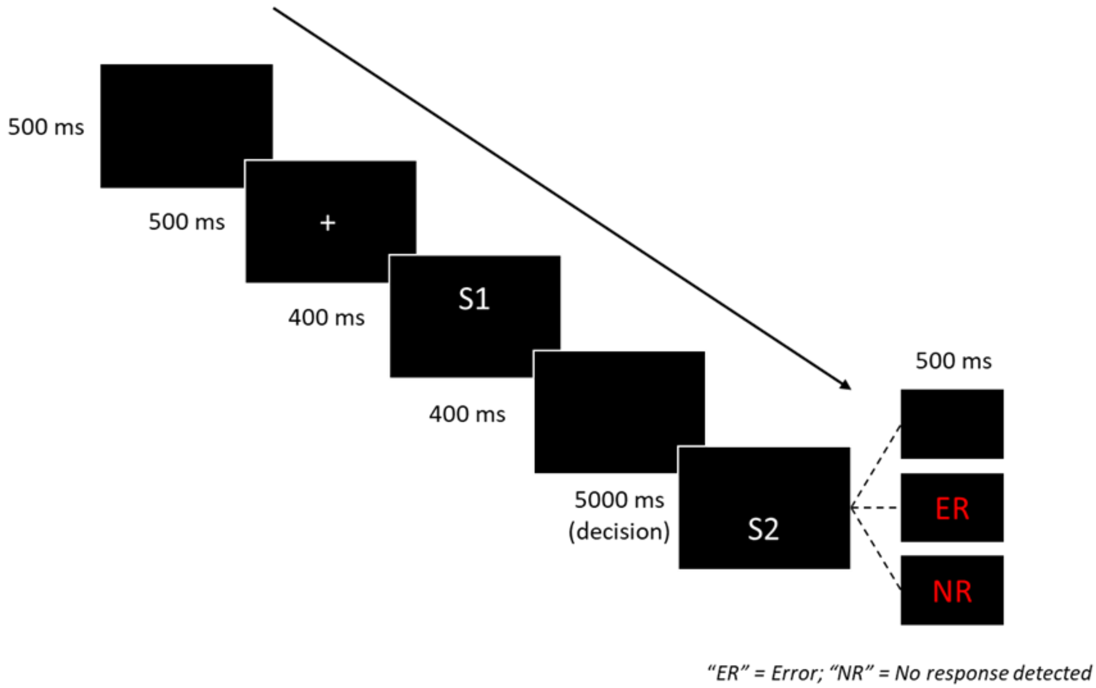

Figure 1. The timeline of a typical trial. S1 denotes the first stimulus that is presented to the participant (the criterion stimulus) and S2 denotes the second stimulus to be presented to the participant (the test stimulus). Feedback is only given on errors and non-responses.

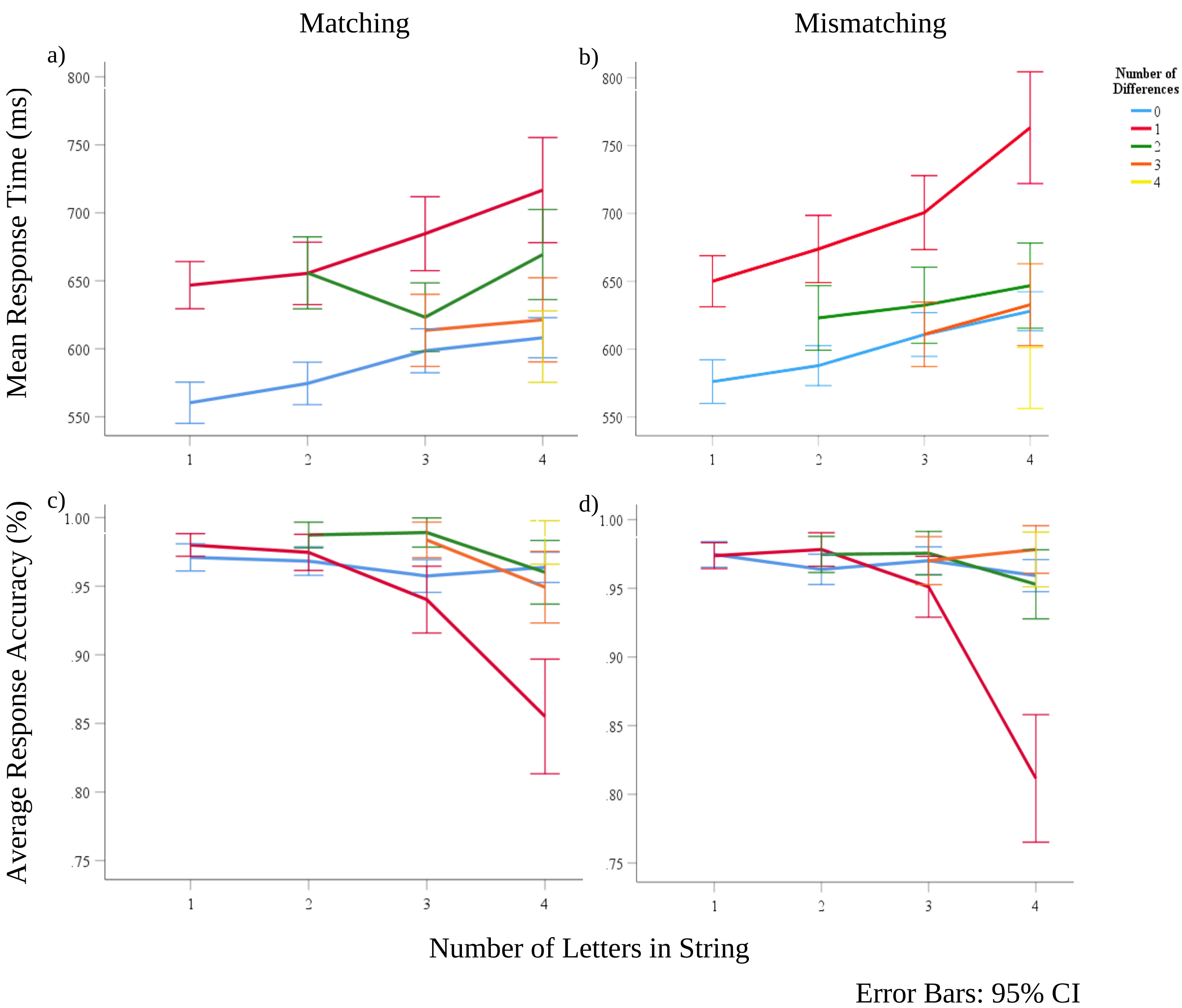

Figure 2. Mean response times (ms) of matching color conditions (a) and mismatching color conditions (b), and average response accuracies (%) of matching color conditions (c) and mismatching color conditions (d), for each trial defined by the string length and number of differences.

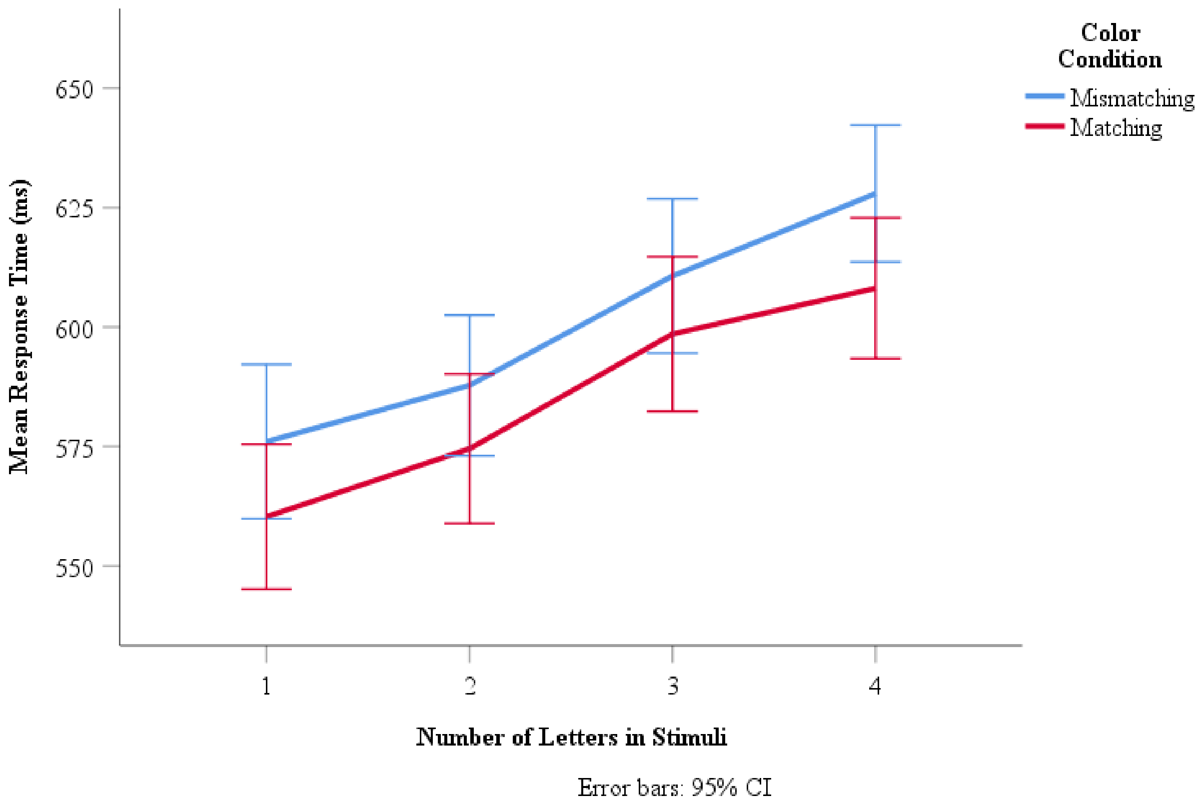

Figure 3. Mean response time (ms) for 'Same' trials defined by the string length, for both matching and mismatching color conditions.