

**Visual, Verbal and Balanced Processing Styles: Exploring the Effects of Attentional Biases
on Decision Making Under Conflict**

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Abstract

Individuals differ in how easily they perceive and internally represent visual and verbal information. However, these differences in information processing style are not all or nothing; individuals vary not only in the direction of attentional bias, but also its strength. Prior research found that when forced to choose between competing visual and verbal stimuli, people exhibit different degrees of bias when selecting what information to attend to. The present study examines whether individuals with greater visual or verbal attentional biases, relative to neutral attenders, show different levels of sensitivity to conflict between visual and verbal information during a categorization task. Data was analyzed from 185 participants who completed a card sorting task in which they were asked to sort stimuli into one of three card suits. We hypothesize that individuals showing a greater attentional bias towards either task modality will ignore information that is misaligned with their preferred information processing style, resulting in a smaller incongruency effect. These results would suggest that biased attenders have quicker access to the information that aligns with their processing style, while neutral attenders notice both information types and experience conflict when they are incongruent. Alternatively, if attentional bias is unrelated to incongruency effect magnitude, this suggests that people process information similarly, and experience biases only at the decision phase. This study has important implications for understanding how individual differences in information processing style affect how much information individuals process in situations with attentional competition.

Individuals process information at a near constant rate and vary considerably in their information processing abilities and strategies. Information processing style is a person's preference for a given mode of information presentation when given a choice between modes. Understanding why people prefer certain modalities over others and the effect this preference

may have on their processing of all modalities is a topic many studies have investigated before. What has not been investigated is how the strength of an individual's bias towards one information processing style affects their attention and information processing. In the present study, we investigate how stronger or weaker bias towards one's information processing style affects information perception, especially when there is an element of conflict involved in the measure.

Previous studies have shown evidence that people process information in different ways. When creating the Internal Representations Questionnaire (IRQ)—a self-report questionnaire analyzing people's internal visualizations and verbalizations—researchers found that preference for either internal visualization or verbalization of information showed consistent differences in information processing ability across people (Roebuck and Lupyan, 2020). Another study using processing style questionnaires assessed people in three different information processing style types: object visual (pictures), spatial visual (schematics/diagrams) and verbal (words). The results indicated that when presented with material that matched a participant's processing style, learning outcomes improved, suggesting that people's information processing style differences do impact their information intake (Thomas, 2010). When investigating how differently individuals might encode the same piece of information, Alfred (2020) found that information that is encoded is most heavily dependent on the information a person attends to; something that is greatly influenced by information processing style. Across a range of information processing style categorization methods, prior research has consistently demonstrated that individual differences in information processing style have a substantial effect on the way that people perceive information.

Visual/Verbal Information Processing Style

One key way that individuals differ in the way they process information is a baseline bias in the degree to which they attend to visual or verbal information. In the past, it was widely believed that people are best at processing information presented in the modality that aligns with their preferred information processing style, however, this is not entirely true (Mayer and Massa, 2003). One study found that when individuals were presented with information in a non-preferred modality, they recruited brain regions that converted the stimulus into the preferred modality (Kramer, 2009). In situations where people were forced to use their non-preferred processing style, they were still able to process the information as efficiently as if it were in their preferred information processing style because they were able to translate it into their preferred modality. A study investigating attentional bias's role in mediating information processing revealed a similar phenomenon, showing that people with a verbal information processing style encoded verbal and visual information using the left supramarginal gyrus (SMG). The activation of the SMG, a brain region used to translate pictures into word form, suggests that people with a verbal information processing style converted visual information into a verbal representation and encoded it that way (Alfred, 2020). Across several studies using different paradigms, individuals consistently have baseline differences in whether they prefer to attend to visual or verbal information. However, it is unclear how the strength of one's attention processing style relates to how they perceive information.

Attentional Bias

Visual and verbal information processing differences have been studied in different ways; however, it is unclear how the degree of a person's bias influences information processing. People differ in the degree to which they pay attention to their preferred information processing style modality. Some people very strictly attend to information that aligns with their information

processing style, only rarely attending to the opposite modality information. Others are more neutral attenders, who show a more even split between the modalities they attend to. This effect is robustly demonstrated in a behavioral task that asks participants to sort cards based on the suit, which are presented showing a word and a picture simultaneously (Alfred, 2020). There are two types of trials. In incongruent trials, the suit picture and suit word do not match, while in congruent trials they do. Incongruent trials where the modalities (e.g., Word: Club and Picture: Heart) do not align, are used to assess and categorize people's information processing style. As depicted in Fig. 1 there are people on the extremes who always choose the picture or always choose the word and there are also people in the middle who do not respond consistently to either the picture or the word. This distribution highlights the fact that preferences for visual/verbal information are not all-or-nothing and raises the question of how the degree of bias towards a given information processing style affects the way information is processed.

One possibility is that attentional bias may influence how much information is initially taken in and, therefore, the degree of conflict experienced when the stimuli are incongruent. It has been well established that individuals take longer to make a response when information is incongruent. For example, in the Stroop task, participants are shown a color word (e.g. the word blue) presented in some color of ink, and people are asked to name the color of the ink, not the color that the word says (Stroop, 1935). During incongruent trials where the word doesn't match its ink color (e.g. the word blue in the ink color red), people show longer response times. As reading is a function that individuals practice daily, it is a more automatic process than naming the color of something. Naming colors occurs much less frequently, and it is difficult *not* to read something if one's attention is brought to it. Because reading is so automatic, being asked to name the color of the ink requires that a person overrides their instinct of reading the word and

instead looking at the ink, forcing them to think more about their answer in order to respond correctly.

How much slower people respond, however, can vary based on individual differences. Long and Prat (2002) found that if the Stroop task had many conflict trials, people with higher working memory capacity employ a suppression strategy that allows them to selectively pay attention to just the color of the word presented and not the word itself. This leads to faster response times as these people are able to ignore one stimulus and respond more automatically. Individuals who display a more biased information processing style on the card sorting task may be using a strategy similar to suppression, where they selectively attend to the stimulus that is presented in their information processing style modality and ignore the other simultaneously presented information. It is therefore expected that people who have a greater response bias will be less impacted by conflict and as a result have a smaller incongruency effect on the card sorting task. On the other hand, people who are more neutral attenders may assess all options before responding, leading to greater conflict when the information is incongruent. Like in the Stroop task, we expect that people who attend to both stimuli (picture and word) will have slower response times and therefore a greater incongruency effect on incongruent trials than people who are more biased attenders. We predict that neutral attenders will assess both options before choosing one, resulting in longer response times, especially during incongruent trials. With the available research, it is unclear how bias influences the intake of information. This project's aim is to investigate how stronger attentional bias towards one's preferred information processing style in the card sorting task affects the degree of conflict experienced on incongruent trials.

Methods

Participants

185 individuals (140 female, mean = 40.05 years) participated in this study. Participant ages ranged from 10 to 87. Four participants declined to provide their age and/or sex.

Participants completed the study measure asynchronously online. All participants were volunteers who gave informed consent prior to participating and did not receive any monetary compensation.

Visual and Verbal Attentional Bias Task

Participants completed four blocks of an online card sorting task (Alfred, 2020). Each block consisted of 48 trials. In each trial participants were simultaneously shown a picture and a word description of one of three card suits: a club, heart, or spade. 75% of the trials are congruent trials, meaning that the visual (picture) and verbal (word) representations of the card suit match (e.g. participant is shown a picture of a heart and the word heart). 25% of trials are incongruent, meaning that the visual and verbal representations of the card suit do not match (e.g. participant is shown a picture of a spade and the word heart). As shown in Fig. 2, the suit representations are aligned one above the other on the screen: on 50% of the trials the picture is on top and on the other 50% the word is on top. Participants are asked to sort the pictured cards based on the suit, using three keys on the keyboard. Incongruent trial responses are used to categorize participants as having a visual or verbal processing style; choosing more words than pictures means a verbal information processing style and choosing more pictures than words means a visual information processing style.

Procedure

All tasks for this study will be administered asynchronously on the online platform PsyToolkit. Participants will give consent, complete a brief demographics questionnaire, and then complete the card sorting task.

Pre-Analysis

Before analyzing the data, two calculations of the bias score and incongruency effect will have to be made. Participants will be given a bias score calculated by subtracting the number of picture responses from the number of word responses and dividing that number by the number of correct trials. Incorrect trials are incongruent trials in which the participant chooses the suit that is not presented on the screen (e.g. the screen shows a picture of a heart and the word spade, and the participant sorts the trial as a club), and these trials are ignored. The bias score lies between -1 and +1, -1 to 0 indicating a visual information processing style and 0 to +1 indicating a verbal information processing style. A bias score of +1 indicates that the participant chooses the word on every trial, -1 indicates they choose the picture on every trial, and a score of 0 indicates that the number of pictures and words chosen is equal. A bias score above 0.8 and below -0.8 (90% of trials selected in one information processing style) indicates a biased attender while a score between those two indicates a neutral attender. Incongruency effect will be calculated by subtracting the mean congruent trial reaction time from the mean incongruent trial reaction time.

Group Analysis

Incongruency effect differences between neutral and biased attender groups will be examined using a t-test based on bias score. An ANOVA will be done on the raw congruent and incongruent reaction times to determine main effects of congruency, attentional bias, and an interaction between the two. Because subjects are categorized as either neutral or biased attenders, an independent samples t-test will be used to assess whether there is a significant

difference in reaction time incongruency effect between the two groups. The ANOVA will analyze the relationship between congruency (incongruent or congruent reaction times) and attentional bias (neutral or biased groups). Because attentional bias is between subjects and congruency is within subject, and both variables have two categories, a 2x2 mixed ANOVA will be used. The main effect of congruency will test if there is a significant difference between incongruent and congruent trial reaction times. The main effect of attentional bias will be assessed to examine the significance between neutral and biased group reaction times. An interaction between congruency and attentional bias will be examined to determine the degree to which participants respond differently to incongruent and congruent trials based on bias group categorization.

Individual Differences Analysis

To investigate the relationship between bias score and incongruency effect, a Pearson's correlation will be completed using absolute bias score and the incongruency effect calculated by subtracting mean congruent trial response time from mean incongruent trial response time. Absolute bias score is used due to biased attender categorization as having either a high verbal information preference or high visual information preference, which are on opposite sides of the information processing style scoring scale. Using absolute bias score folds the data in half and assesses individuals based on degree of bias regardless of information processing style. A negative correlation would mean that as bias increases, incongruency effect decreases, meaning that more biased people have a smaller difference in response times for incongruent versus congruent trials while more neutral attenders show a greater response time difference between the two. A positive correlation would mean that as bias increases, incongruency effect also

increases, indicating that biased attenders show a greater difference in response times for the two trial types than neutral attenders.

Hypothesized Results

In the present study we hypothesized that people with higher bias towards a given information processing style would take in less competing information resulting in faster response times and a smaller incongruency effect. If this hypothesis is supported, we expect there to be a smaller difference between congruent and incongruent trial response times for biased attenders, as they are experiencing less conflict on incongruent trials and selecting the most readily available answer which aligns with their information processing style. A tendency to pick the most available answer would tell us that they are more likely to be biased towards information that aligns with their information processing style. Conversely, we expect more neutral attenders to show a greater incongruency effect, as they will be more aware of both modalities. Attending to both modalities means that neutral attenders will assess all options before making a response, taking more time than biased attenders on incongruent trials, resulting in a greater incongruency effect. This pattern of results would tell us that they are more likely to take their time making a response and show less of a bias. We also hypothesize that reaction times will be slower for incongruent trials than for congruent trials overall, as regardless of degree of bias, it is expected that people slow down somewhat when information presented does not align. Furthermore, we expect that an interaction could occur, such that neutral attenders will have a larger difference between incongruent and congruent reaction times than biased attenders. If the pattern of results does not support our hypothesis and attentional bias is unrelated to the magnitude of incongruency effect, this suggests that people process information similarly, and

only experience biases at the decision phase. This indicates that information processing style impacts the information that people attend to, but the degree of bias has little effect on attention, making it an issue that is not as prominent of an obstacle. Additionally, if the results did not support our hypothesis and showed that biased attenders were taking longer than neutral attenders, this would mean that biased attenders are the group more perceptive to and affected by conflict.

Future research may investigate whether people change information processing strategies or remain stable, and how these groups differ in their conflict perception. Regardless of the results, this research will add to the pool of knowledge surrounding differences in how people perceive information and will allow developments in learning environments.

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Figure 1

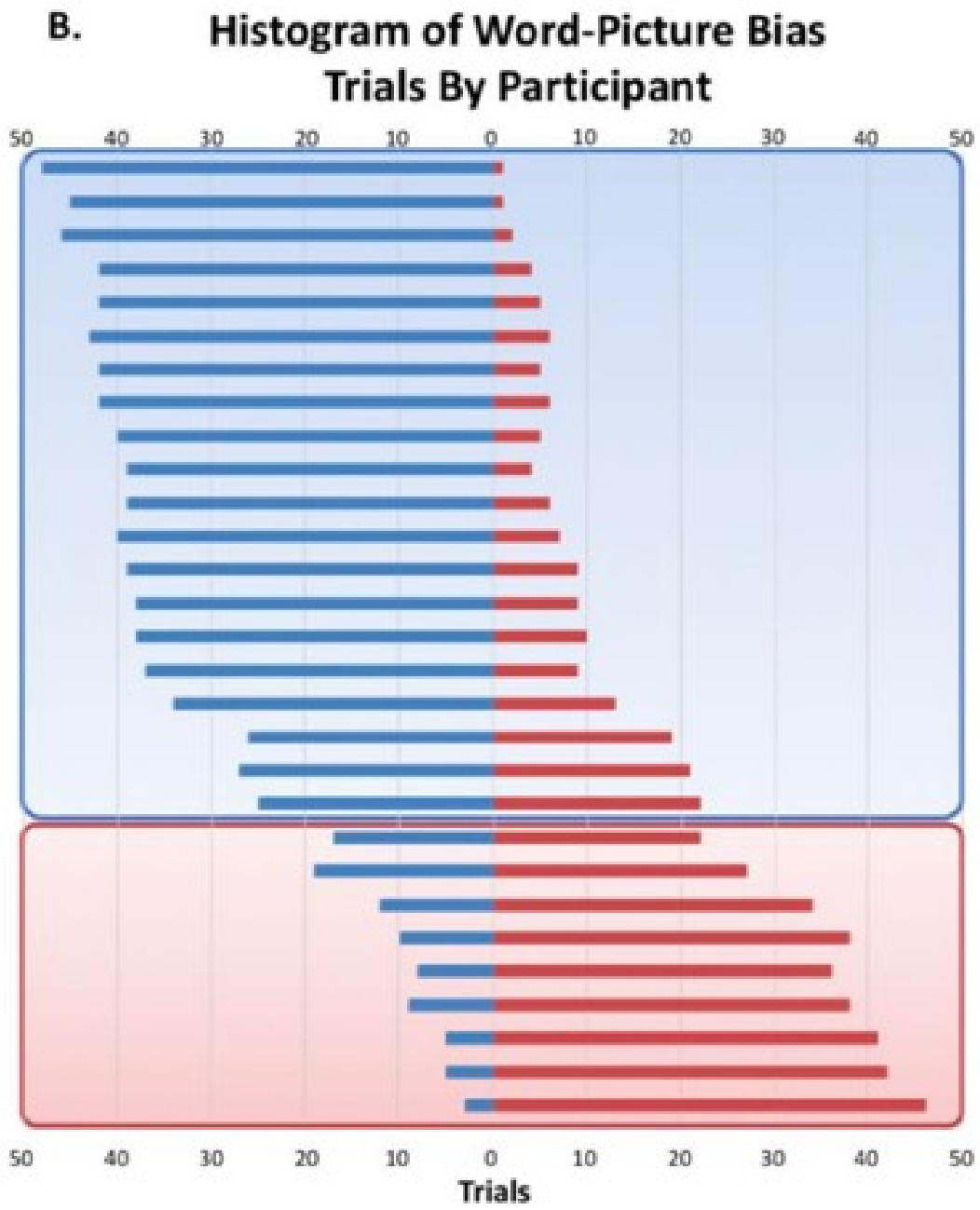


Figure 2

Congruent



Incongruent



Figure Captions

1. The distribution of individuals' bias towards either visual (blue) or verbal (red) information as measured by the card sorting task.
2. An example of the difference between congruent (left) and incongruent (right) trials shown to participants in the card sorting task