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Political Ideology and Persuasion: Systematic and Heuristic Processing Among Liberals and Conservatives

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Two studies explored the relationship between political orientation and the systematic and heuristic processing of persuasive messages. In Experiment 1, liberals, but not conservatives, differentiated between strong and weak arguments in their evaluations of argument quality, indicating the use of systematic processing. In Experiment 2, more attitude change was observed among liberals, than among conservatives, in response to strong messages compared to weak messages, again suggesting the use of systematic processing in liberals. Attitude shift was observed among conservatives, however, in the presence of a source similarity cue, indicating the use of heuristic processing. The results suggest that the divergent psychological motivations of liberals and conservatives may lead them to process information in distinct ways and be susceptible to different types of persuasive strategies.

Introduction

Many people assume that the key to persuasion is the ability to generate strong, compelling arguments that induce agreement in the audience. Indeed, common knowledge dictates that the content of a message determines how persuasive that message will be. In the political world, for example, candidates for office partake in debates, where they articulate their issue positions to voters through reasoned, structured arguments. However, political candidates also employ other strategies to convince voters to support them. Very often they make use of emotional appeals, catchy slogans, and references to group identity to garner support. Political rallies are rife with these types of heuristics-based persuasion tactics. Are strong arguments or gut-level appeals to shared identity more persuasive?

We argue that the answer to this question depends on the political leanings of the audience. Political strategists and social scientists have long recognized that political orientation and ideology determine how the contents of a political message will be received. For example, one expects liberals and conservatives to disagree on the merits and drawbacks of affirmative action or legalized abortion. In this paper, however, we argue that the political orientation of the message recipient also plays a role in determining which persuasion tactics are likely to be most effective, independent of message content. The current studies tested the proposition that political orientation is related to the use of systematic and heuristic processing of persuasive messages. This notion has clear

implications in the political domain, but it has important consequences in daily life as well.

Information Processing and Persuasion

Given the broad relevance of persuasion, it is not surprising that it has been one of the most widely studied processes in social psychology. Decades of persuasion research have emphasized two distinct routes to persuasion: the central route and the peripheral route. According to the Elaboration Likelihood Model (Petty, Cacioppo, & Goldman, 1981; Petty & Cacioppo, 1984), the central route involves attempts to change the attitudes of a message recipient through the use of message-relevant information, whereas the peripheral route involves the use of cues that are not directly relevant to the content of the message. When the message recipient cares about the issue at hand and has the cognitive resources available to think about it at length, the central route should be relatively more effective than the peripheral route in producing attitude change. Conversely, when the issue's personal relevance is low, or when the cognitive resources of the message recipient are limited, the peripheral route should produce greater attitude change (e.g., Cacioppo, Petty, Kao, & Rodriguez, 1986; DeBono & Snyder, 1992).

In a related model, Chaiken and colleagues emphasized the role of information processing in persuasion, distinguishing between systematic and heuristic processing. Systematic processing involves effortful engagement with the content of

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a message and careful evaluation of the merit or validity of an argument (Chaiken, 1980). For example, an individual might analyze the strengths and weaknesses of a message before deciding whether or not it is valid. The central route to persuasion is most effective when the individual processes the content of the message systematically, which requires adequate cognitive resources and high levels of motivation. Heuristic processing, on the other hand, involves the use of mental shortcuts to arrive at a conclusion quickly and easily, i.e., without having to engage in effortful, in-depth processing of the message itself (Chaiken & Eagly, 1983). For example, the recipient might infer that a message is valid—and change his or her attitudes accordingly—when the message is delivered by an expert source. The length of a message may also serve as a heuristic about its validity, providing the message recipient with a way to reach a conclusion without having to evaluate the quality of the message itself (Chaiken, 1980). Thus, the peripheral route to persuasion is most successful when the recipient of the message engages in heuristic processing, tuning in to external cues to quickly and efficiently evaluate a message.

Research suggests that individuals are more likely to use heuristic processing when they are distracted, or when they are unable—or lack the motivation—to process information in a thorough, systematic manner. For example, Chen, Schechter, and Chaiken (1996) showed that when participants were motivated to be accurate in forming new opinions about a topic, they processed information systematically and their attitudes were unbiased by their discussion partner's opinions. When participants were motivated to get along with their discussion partner, however, and were therefore less concerned about the accuracy of the information they received, they relied on their partner's attitudes in generating their own opinion. Furthermore, Mackie, Worth, and Asuncion (1990) showed that when a message was relevant to participants' in-group, they processed the message systematically, and only strong messages led to

attitude change. When the message was delivered by a member of the in-group but the content of message was irrelevant to the in-group, participants relied on heuristic processing to respond to the message, accepting the attitudes advocated by the in-group regardless of argument strength.

Research has also identified individual differences in the chronic use of systematic versus heuristic processing. For example, style of information processing has been linked to the need for cognitive closure, which refers to the psychological motivation to pursue quick and decisive answers to life's questions (Webster & Kruglanski, 1994). Individuals who are high on need for closure have been found to rely on heuristic cues to a greater extent than those who are low on need for closure (Kruglanski & Freund, 1983). In other words, if the motivation to reach an immediate conclusion is high, individuals should be more likely to take advantage of any available mental shortcuts to reach a definitive conclusion. On the other hand, individuals who are motivated to think in complex ways (marked by a "need for cognition") should process incoming information more thoroughly, taking care not to jump to conclusions based on incomplete information. In line with this reasoning, research has demonstrated that individuals who score higher on the need for cognition scale tend to employ systematic processing to a greater extent than those scoring low on the scale (Cacioppo et al., 1986; Cacioppo, Petty, & Morris, 1983).

The Psychological Correlates of Political Ideology

After World War II, a vocal group of researchers denounced political ideology as a meaningless construct, claiming that the terms "conservative" and "liberal" were no longer useful politically or psychologically (e.g., Durrheim, 1997; Ray, 1988). Recent research by Jost and others (e.g., Jost, Glaser, Kruglanski, & Sulloway, 2003; Jost, 2006) has contradicted these claims, demonstrating reliable associations between political ideology and corresponding psychological and political variables. It is becoming

increasingly clear that political ideology is a relevant construct, not only during an election season, but also in a variety of non-political domains. It appears that knowing whether someone is liberal or conservative provides information about how the individual tends to think, feel, and act in daily life. If this is the case, do liberals and conservatives also differ with regard to how they process persuasive messages? The current study serves as one of the first experimental investigations into this question.

In a meta-analysis of 88 previously conducted studies, Jost, Glaser, Kruglanski, and Sulloway (2003) demonstrated that political ideology is associated with a set of related underlying psychological needs. Specifically, they found that conservatives and liberals differ in terms of the types of epistemic needs that motivate them. Conservatives tend to score higher on need for cognitive closure, which may motivate them to pursue quick, unambiguous answers to life's questions. Liberals, on the other hand, tend to score higher on need for cognition (Sargent, 2004). This means that they may prefer to process information deeply and engage in considerable deliberation before arriving at any definite conclusion.

We propose that the aforementioned psychological differences between conservatives and liberals have implications for their use of systematic and heuristic processing in a persuasion context. Given that liberals tend to have a higher need for cognition, they should be more likely than conservatives to process persuasive messages systematically. Given that conservatives tend to have a higher need for closure, they should be more likely than liberals to process persuasive messages heuristically.

To test these predictions, we asked participants across the country to rate various counterattitudinal arguments in terms of their strength and persuasiveness. Traditional persuasion research paradigms provide participants with strong and weak arguments to determine whether different groups of participants distinguish between the two.

Participants who are able to differentiate between strong and weak arguments are inferred to engage in systematic processing (e.g., Chaiken & Maheswaran, 1994). Accordingly, we hypothesized in Experiment 1 that participants who rated themselves as liberal would differentiate between strong and weak arguments to a greater extent than those who identified themselves as conservative.

EXPERIMENT 1

Method

Participants

Participants were 108 adults from around the United States recruited to an online survey through an advertisement on the Facebook website. Fifty-six of the participants were undergraduates, 24 had recently earned their Bachelor's degrees, and 22 were graduate students. Gender information was not collected.

Design

The study employed a $2 \times 2 \times 2$ between-subjects design. Independent variables were participant ideology (conservative or liberal), quality of arguments (strong or weak), and message topic (comprehensive exams or tuition increase). Participant ideology was measured with three items toward the end of the survey asking participants to rate how liberal or conservative they were in general, on economic issues, and on social issues (1 = very liberal, 7 = very conservative). The item concerning political ideology on economic issues produced the least liberally skewed distribution ($M = 3.68$, $SD = 1.69$), so we used this item to classify participants as either liberal or conservative. While economically related political issues represent just one subset of the political beliefs that comprise an individual's ideology, we believe that they serve as a good representation of participants' political orientation. In the participant pool used in this study, the correlation between self-rated general political

orientation and self-rated political orientation on economic issues was very high ($r = .817$).

Participants were divided into groups according to the mean and median responses on this measure, whereby those who rated themselves as 1, 2, or 3 were categorized as liberal, and those who rated themselves as 4, 5, 6, or 7 were categorized as conservative. This classification procedure resulted in the 54 most liberal participants being categorized as liberal and the 54 most conservative participants being categorized as conservative.

Materials And Procedure

Participants followed a link to the survey and completed it anonymously. In this study, we drew two commonly used topics and 20 arguments (10 for each topic) from previous persuasion studies. Discussion topics were counterbalanced across conditions to allow for generalization of the results beyond a single attitudinal domain. Participants assigned to the “comprehensive exams” topic condition read arguments in favor of implementing comprehensive examinations for college seniors (Petty & Cacioppo, 1986). Participants in the “tuition increase” topic condition read arguments in favor of increasing tuition at universities (Darke & Chaiken, 2005). Arguments were generally counterattitudinal: college students typically oppose both the institution of comprehensive exams and increases in tuition.

Participants evaluated either five strong or five weak arguments about the topic to which they were assigned. Pilot data from previous research showed that these arguments were either strong or weak (see Darke & Chaiken, 2005; Petty & Cacioppo, 1986). An example of a strong argument for increasing tuition was that the university could use the extra revenue to fund the addition of more computer labs and upgrade technology in the classroom. The corresponding weak argument was that the university needed the money to beautify its campus. Participants in the current study rated the strength and persuasiveness of each argument using a 6-point scale (1 = not at all strong/persuasive, 6 = very strong/persuasive). They then rated the

five arguments as a set on these same dimensions. Finally, they provided information about their political ideology and their level of education.

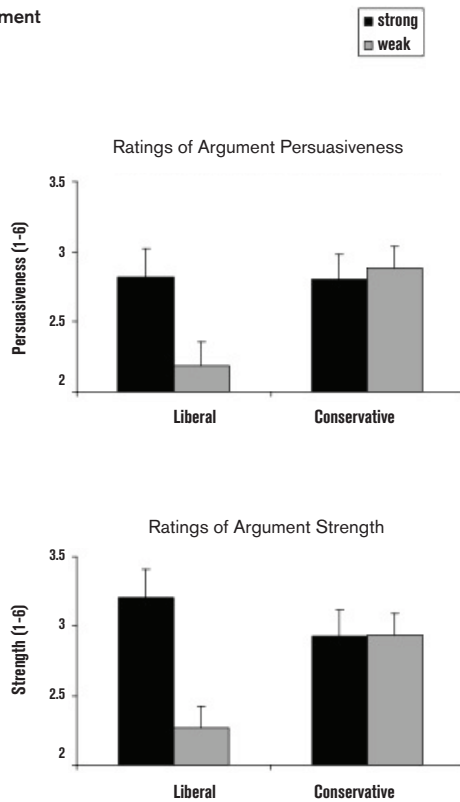
Results

We hypothesized that liberals would engage in systematic processing to a greater extent than conservatives; an Analysis of Variance (ANOVA) supported this prediction. The results revealed that there was a significant main effect of argument quality on participants' ratings of argument strength ($F(1, 104) = 10.47, p = .002$). However, there was a significant interaction between argument quality and participant ideology ($F(1, 104) = 4.793, p = .03$), whereby liberals' ratings of strength differed between the strong- and weak-argument conditions, and conservatives' ratings of strength did not. A Tukey HSD post-hoc test was used to analyze the differences in overall strength ratings, collapsed across discussion topics. Figure 1 illustrates the results. In line with predictions, liberals rated strong arguments as being significantly stronger ($M = 3.21, SD = 1.03$) than weak arguments ($M = 2.27, SD = .78$), $p = .001$. Conservatives, on the other hand, did not differentiate between strong ($M = 2.96, SD = .93$) and weak ($M = 2.77, SD = .85$) arguments in terms of their perceived strength, $p = .88$.

A similar pattern was observed for ratings of persuasiveness. As shown in Figure 1, liberals perceived strong arguments to be marginally more persuasive ($M = 2.82, SD = 1.06$) than weak arguments ($M = 2.19, SD = .85$), $p = .06$. Once again, conservatives did not differentiate between the persuasiveness of strong arguments ($M = 2.78, SD = .85$) and that of weak arguments ($M = 2.57, SD = .90$), $p = .83$. In sum, liberals gave higher ratings to strong arguments than to weak arguments, but conservatives did not differentiate between the arguments based on quality. These findings support our predictions and suggest that liberals engaged in systematic processing, whereas conservatives did not.

Figure 1

Mean ratings of argument persuasiveness and strength as a function of participant ideology and argument strength.



Discussion

The results of Experiment 1 supported the prediction that, when faced with a persuasive appeal, liberals would process the information systematically, whereas conservatives would not. The differences in the ratings of strength and persuasiveness of strong and weak arguments among liberals suggest that liberals systematically processed the content of the arguments. Conservatives, on the other hand, did not differentiate between strong and weak arguments, which suggests that they did not engage in systematic processing. Data on the initial attitudes of the

participants toward the discussion topics showed that liberals were slightly more opposed to comprehensive exams and conservatives were slightly more opposed to increases in tuition before reading any of the persuasive arguments. The results held consistent across topics despite these differences, making it highly unlikely that the effects found were due to the particular topics used. Thus, Experiment 1 provides initial evidence in support of the predicted relationship between political orientation and the processing of persuasive messages. However, Experiment 1 did not address the relationship between political orientation and the use of heuristic processing. To test the idea that liberals and conservatives would also differ in the extent to which they drew on heuristic cues in processing persuasive appeals, we conducted Experiment 2.

As previously mentioned, liberals and conservatives tend to differ in the epistemic needs that motivate them (Jost et al., 2003). Given conservatives' higher needs for cognitive consistency, one might expect this group to resist overt persuasive attempts to a greater extent than liberals. It would seem that maintaining consistency in their beliefs over time would satisfy the elevated epistemic need for closure observed among conservatives. However, under certain conditions, it may also be possible to satisfy epistemic needs for certainty through attitude change rather than through resistance to persuasion.

How might changing one's attitude in response to a persuasive appeal serve the desire for certainty? According to the theory of shared reality (Hardin & Higgins, 1996), satisfying relational needs can simultaneously satisfy epistemic needs. A relational need is the need to relate to others, creating and maintaining social relationships and establishing a sense of shared reality with others. According to some researchers, cognition and social relationships are completely interdependent (Hardin & Conley, 2000). In other words, by establishing a sense of consensus with a relevant other, one is able to experience a sense of certainty in one's thoughts and

beliefs (Hardin & Higgins, 1996). When our perceptions are shared with relevant others, transient, ambiguous intuitions become objective reality. Consistent with this reasoning, a recent study found that individuals who had high epistemic motivation (in this case, the desire to acquire knowledge about the situation at hand) aligned their implicit attitudes with the attitudes endorsed by their interaction partner (Lun, Sinclair, Whitchurch, & Glenn, 2007). Furthermore, Kruglanski, Pierro, Mannetti, and De Grada (2006) concluded, on the basis of a broad review of the literature, that a high need for closure, another type of epistemic motivation, led group members to seek shared reality with one another through emphasis on speedy consensus, unambiguous group stances on issues relevant to the group, and opinion uniformity among group members. Based on this collection of research, we hypothesized that conservatives, given their greater needs for epistemic certainty, would be more likely to change their attitudes in response to a persuasive attempt when a favorable relational cue—which could be conceptualized as a type of heuristic—was available.

In Experiment 2, participants were presented with either strong or weak messages in favor of raising tuition at NYU. Half of the participants in each group were also provided with a heuristic cue about the source of the message. Participants in the similarity cue condition were told that they shared their birthday and home state with the person delivering the persuasive message. This similarity manipulation was used because sharing a birthday has been shown to induce feelings of similarity, even though no information about shared attitudes or values is conveyed (Miller, Downs, & Prentice, 1998). The heuristic used in the present study is interpersonal in nature: information about what similar others think about an issue can be used as a clue as to what individuals themselves should think. This type of cue is most likely to be used by individuals who are motivated to get along with an interaction partner (Chen et al., 1996). The perception of similarity to the source of a message may

thereby result in attitude change, even in the absence of strong arguments.

Although the link between this type of relational influence and political orientation has not yet been demonstrated directly, recent research in this domain does suggest that political attitudes shift to reflect the attitudes of significant others (Jost, Ledgerwood, & Hardin, 2008). In addition, some evidence exists to suggest that conservatives value conformity to a greater extent than liberals do (Jost, Nosek, & Gosling, 2008). Thus, we expected conservatives to be more motivated to share reality with similar others, and to therefore be more likely to succumb to persuasion on the basis of perceived similarity to the source. Accordingly, in Experiment 2, we hypothesized that conservatives' attitudes would shift more in the direction of a persuasive appeal when a similarity cue about the source was available than when such a cue was not provided; we did not expect conservatives' attitudes to change as a function of argument strength. We further hypothesized that liberals' attitudes would shift more in the direction of a persuasive message when argument quality was strong rather than weak; we did not expect liberals' attitudes to change as a function of perceived similarity.

It is important to note that, in Experiment 1, we assessed the strength attributed to various arguments by participants themselves, rather than the amount of actual change in participants' attitudes. It is possible that an argument would be perceived to be strong and persuasive but not change the attitude of the message recipient. To rule out this possibility, the dependent variable in Experiment 2 was a measure of attitude change subsequent to exposure to persuasion.

EXPERIMENT 2

Method

Participants

Participants were 64 undergraduate students (17 men and 47 women) at New York University, who

participated in the study in exchange for partial course credit. All participants were currently enrolled in an Introduction to Psychology course, and all participants had completed a large battery of questionnaires at the start of the semester (i.e., a minimum of four weeks prior to the study). The battery assessed (among other psychological variables) participants' self-reported political orientation, date of birth, and home state. The current study was described as an experiment investigating the effects of different modes of communication, and participants were free to sign up for the study from a larger list of studies available to them.

Political orientation was again assessed in terms of self-placement on economic issues, this time using an 11-point ideological spectrum (1 = very liberal, 11 = very conservative). For the purposes of the current study, we categorized participants as liberal if they fell into the bottom quartile of the student sample distribution on this item and conservative if they fell into the top quartile. Moderates, or the middle two quartiles of the sample, were allowed to participate in the experiment but were excluded from analyses. Liberal and conservative students who had participated in the battery were also invited to participate in the current study via e-mail. The study was described in the e-mail as a study investigating "Modes of Communication."

Design

The study employed a 2×2×2 between-subjects design. Independent variables were participant ideology (conservative or liberal), quality of argument (strong or weak), and similarity cue (similar or non-similar). Participants were randomly assigned to one of the two argument quality conditions and one of the two similarity cue conditions, with the following exceptions: Six of the participants in our study had the same home state or birthday as in the generic information used to describe the purported interaction partner presenting the persuasive message—these participants were assigned to the similarity cue condition. This

was done to ensure that all participants either shared both a birthday and home state with their partner or did not share either. Five of the participants were international students—these participants were assigned to the no similarity cue condition, because in most cases, it would have been obvious that the partner was not from their home countries. The number of participants that deviated from random assignment is somewhat high, but this was unavoidable, given our need to create clear divisions between the levels of perceived similarity in the similarity cue and no similarity cue groups. Furthermore, the participants who were not randomly assigned to a similarity condition were randomly assigned to the argument quality conditions and evenly distributed across ideology conditions, making it unlikely that the lack of random assignment had any systematic effect on the results. The dependent variable was the amount of attitude change in the direction of a persuasive appeal in support of a tuition increase at NYU.

Materials and Procedure

Participants arrived at the laboratory in groups of one to four, expecting to partake in a study called "Modes of Communication." A female experimenter provided the following instructions, which provided the basis for our cover story:

"Today we'll be looking at the effects of different modes of communication. All of you are randomly paired up with another student who's begun the experiment down the hall. You all [or 'you,' or 'you both'] have been assigned to the role of 'receiver' and your partners down the hall are the 'senders.' In this role, you will receive information from your partner, the sender, and you will answer some questions about that information and how it was communicated. There will be three modes of information: written, videotaped, and in-person."

Participants were then led to separate rooms to complete the experiment individually. In reality, all participants were receivers of communication and received information about the same fictitious person.

Initial Attitudes Toward Increasing Tuition

Participants first completed a basic questionnaire about their attitudes toward various topics. One of the topics included in the questionnaire was increasing tuition at NYU. Support for increased tuition was measured on an 8-point scale (1 = strongly oppose, 8 = strongly support). This item provided a baseline measure for attitudes toward a tuition increase. Filler topics included on the questionnaire were Harry Potter, math, plastic surgery, New York City, and classical music.

Similarity Cue Manipulation

Participants were reminded that they would be interacting with their study partner later in the experiment. Each participant was then asked to complete a basic information sheet about him- or herself. Participants were asked to provide their birthday and home state on this questionnaire. Participants were told that all participants in the study would complete the information sheet, but that only the “receivers” would have access to the responses of their partners.

After completing the information sheet about themselves, participants were handed a bogus information sheet and told that this information sheet had just been completed by their interaction partners. The bogus information sheet had actually been completed by the experimenters prior to the study. Across all conditions, the partner was presented as a male sophomore named Seth. In order to manipulate the presence of a similarity cue, half of the bogus information sheets were completed so as to indicate that Seth was from the same home state as the participant and shared the participant’s birthday. The other half of the information sheets indicated that Seth was from Michigan and was born on February 10, 1989.

Similarity Manipulation Check

Each participant then completed a questionnaire about the effectiveness of Seth’s information sheet as a written mode of communication. The questionnaire consisted mostly of filler items designed

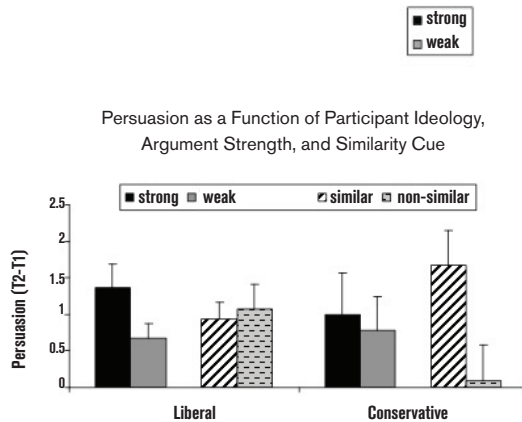
to enhance the study’s cover story. Embedded in the questionnaire were manipulation check items assessing the extent to which participants felt similar to their study partner and the extent to which they felt motivated to relate to him.

Persuasive Message

Each participant was instructed to check his or her e-mail for a video message from the purported interaction partner. Participants watched a 7-minute video, supposedly recorded during the same experimental session in another room across the hall. The video featured Seth, the bogus interaction partner (played by a trained actor), explaining the reasons for his support of a tuition increase at NYU. Participants were told that the discussion topic had been chosen by their partners from the list of attitudes they saw at the beginning of the study. In reality, all participants received a message about the same topic. To manipulate argument strength, half of the participants received a video that contained four strong arguments in favor of increasing tuition, and the other half received a video that contained four weak arguments in favor of increasing tuition. The arguments used here were a subset of the tuition increase arguments used in Experiment 1. Once again, argument strength was previously established (see Darke & Chaiken, 2005). We modified the arguments to a more naturalistic speaking style, but the content and logic used in the arguments were the same as in previous studies. Corresponding pairs of strong and weak arguments shared the same sentence structures and syntax, only changing key words to alter the content of the message. In order to control for any potential effects of a particular personal or speaking style on attitude change, two different actors were employed to play the role of Seth. Each actor was recorded delivering one video featuring a strong message (i.e., consisting of four strong arguments) and another video featuring a weak message (i.e., consisting of four weak arguments). Videos were reviewed by four observers to ensure that strong and weak videos were virtually identical in terms of non-verbal cues and delivery,

Figure 2

Mean persuasion in favor of increasing tuition at NYU as a function of participant ideology, argument strength, and similarity cue.



and different only in message content. Videos featuring the two actors were counterbalanced across conditions.

Attitudes After Persuasion

Immediately after watching the video, participants completed a questionnaire about the effectiveness of the video as a mode of communication. To enhance the study's cover story, each participant was first asked to select from a list the topic that his or her partner had discussed in the video. Participants were then asked to report their attitudes toward increased tuition a second time. Participants again rated their support for increased tuition on an 8-point scale (1=strongly oppose, 8=strongly support). Finally, the questionnaire asked participants to list their thoughts about the video and evaluate the communication style of their partner.

Before debriefing, participants were probed for suspicion about the study's cover story. They were then informed by the experimenter that there would be no in-person interaction, fully debriefed, and thanked for their participation.

Results

Final persuasion scores were calculated by subtracting participants' Time 1 attitudes toward increasing tuition from their attitudes toward the same issue at Time 2 (i.e., after persuasion). There were no significant differences in attitude change between men and women, $t(62)=.377$, ns, so gender differences will not be discussed further. Attitude change was comparable across the two actors used in the recording of the persuasive messages, $t(62)=.815$, ns. The manipulation check of the similarity cue indicated that participants in the similarity cue condition did, in fact, feel more similar to their study partner ($M=5.24$, $SD=1.29$) than those in the no similarity cue condition ($M=4.26$, $SD=1.39$), $t(62)=3.54$, $p < .01$. Ten participants indicated suspicion of the experiment's cover story and were excluded from further analyses. Although this number is somewhat high, the attrition rate was approximately equal across conditions, and therefore likely had little effect on the results.

All data were analyzed using an ANOVA. There was a significant interaction between similarity condition and ideology on persuasion ($F(1, 48)=5.12$, $p < .03$), whereby the extent of attitude change in conservatives differed depending on similarity cue condition while attitude change in liberals did not. As shown in Figure 2, conservatives in the similarity cue condition ($M=1.67$, $SD=1.67$) shifted their attitudes in favor of increasing tuition to a greater extent than did conservatives in the no similarity cue condition ($M=.09$, $SD=1.64$), $F(1, 27)=5.20$, $p < .04$. Conservatives' mean levels of persuasion did not, on the other hand, differ between the strong argument condition ($M=1.00$, $SD=2.06$) and the weak argument condition ($M=.78$, $SD=1.39$), $F(1, 21)=.08$, $p=.78$. These findings suggest that the heuristic cue of source similarity was more effective in inducing persuasion among conservatives than was a strong persuasive message.

Also in line with predictions, liberals were more persuaded by strong arguments ($M=1.36$, $SD=1.22$) than by weak arguments ($M=.67$, $SD=.82$), $F(1, 27)=3.27$, $p=.08$. Although this difference is

only marginally significant, we predict that it would reach the $p < .05$ alpha level if our sample size (and statistical power) were larger. The mean persuasion scores of liberals who received a similarity cue ($M = .93$, $SD = .88$) did not differ from those of liberals who did not receive such a cue ($M = 1.07$, $SD = 1.27$), $F(1,27) = .12$, $p = .74$. In other words, strong arguments effectively induced persuasion among liberals, but the heuristic cue of similarity did not have such an effect.

General Discussion

The results of these two studies support our hypotheses. In both studies, liberals' susceptibility to persuasion depended primarily on argument strength. Liberals perceived stronger arguments to be stronger than weak arguments in Experiment 1, and they demonstrated greater attitude change in response to a strong message versus a weak message in Experiment 2. Thus, liberals processed persuasive messages in a systematic manner. Conservatives, on the other hand, did not appear to engage in systematic processing, showing no differences between argument strength conditions in perceived argument strength or attitude change.

In Experiment 2, liberals did not demonstrate susceptibility to cues of similarity. Evidently, liberals were more likely to focus on the content of a persuasive message and less likely to take advantage of the mental shortcuts that heuristic cues would provide. Further research should elaborate on the current findings by directly establishing and clarifying the role of liberals' psychological needs in their systematic processing. In Experiment 2, conservatives exhibited heuristic processing, shifting their attitudes toward those of an interaction partner when a similarity cue about the source was provided. More research needs to be done to clarify exactly which psychological processes are involved when conservatives prioritize the heuristic cues surrounding a message over the content of that message.

The results of this study support the notion that the content of a message is not the only factor that determines how the message is received. The myriad factors involved in the presentation of a message can significantly influence people's response to it. Furthermore, these factors seem to influence different types of people in different ways. It is important to note that systematic processing is not inherently superior to heuristic processing. Depending on the situation, either mode of processing may prove advantageous over the other. Certain decisions may involve complex considerations and require careful weighing of the alternatives, whereas other situations may require quick and efficient decision-making. For example, when buying a new car, it is wise for a consumer to gather information about his or her options ahead of time, rather than depending on the car dealer to provide accurate, trustworthy information. When caught in a fire, on the other hand, stopping to evaluate all of the possible responses will only put the individual in danger; a much more adaptive strategy is to simply follow the cues provided by a firefighter. Both types of processing can be useful in daily life, as individuals navigate through the wealth of information constantly available to them in the environment.

Implications

These two studies are, to our knowledge, the first to directly investigate the relationship between political ideology and the processing of persuasive messages. The findings provided here shed light on the psychological differences between conservative and liberal individuals. In doing so, the current research has significant implications for persuasion research as well as for political psychology and social psychology at large. Ideological groups reflect very real divisions in our society, and membership in such groups has meaningful consequences for the individual. After decades of theoretical arguments and correlational data, the current study offers experimental evidence in support of the view that political ideology is, in fact, a meaningful

construct in the persuasion context and in everyday life. We have demonstrated that ideology can have a substantial influence on interpersonal interaction and on how incoming information is processed. Contrary to what some theorists have claimed (e.g., Durrheim, 1997; Ray, 1988), political ideology remains a meaningful construct in the study of psychology and society at large. The current study provides strong support for this argument.

In light of the consequential implications of the current study, it is important to discuss some of its limitations. One major limitation was the ideological composition of the participant pool in the present studies. Although we attempted to recruit an ideologically balanced group of individuals in Experiment 2, questions remain about the meaning and psychology of conservatism in a politically liberal university in New York City. It is possible that membership in an ideological minority group results in psychological motivations that differ from those that stem from membership in the majority group. We believe that the results from Experiment 2 would be even more pronounced in a more ideologically balanced context. However, we cannot generalize our findings to the American population at large until the results have been replicated in other regions of the country. On the other hand, Experiment 1 was conducted with participants from across the country and led to findings that were consistent with Experiment 2. Further studies in more politically conservative locations and with older participants would help to reinforce the results of the current study.

Another possible limitation in the current study was the way in which political orientation was operationalized. While some might argue that political beliefs about economic issues only capture part of an individual's political ideology, we found them to be highly correlated with general political orientation. Furthermore, American colleges—and NYU in particular—tend to be more socially liberal than the population at large. There are fewer socially conservative individuals present, and their status as the political minority might make them less likely to be

honest about their social beliefs in an experiment. Therefore, categorizing participants based on their beliefs about economically related political issues produced a more ideologically balanced sample and likely led to more accurate self-ratings from participants.

Finally, some might argue that the strong arguments used in the studies could have represented values that were more liberal in nature, rather than being “objectively” more strong, and the weak arguments could have represented values that were more conservative in nature, rather than being “objectively” more weak. However, the current study employed two different discussion topics for Experiment 1 and achieved consistent results across the two topics. For this reason, it seems unlikely that the results observed were uniquely produced by the particular arguments used in the study. Future research should employ a variety of discussion topics to further clarify which types of arguments might be considered “objectively” strong and to confirm whether the pattern of results found in this study is generalizable across different attitudinal domains.

Despite the aforementioned limitations, the current study has important implications. Although it is easy to grasp the relevance of political groups in the context of an election season or a political event, it is important to remember that ideology also has consequences in everyday life. In our study, conservatives and liberals processed a persuasive message in two very distinct ways, even though the message content did not involve explicitly political or ideological issues. By showing that differences between liberals and conservatives extend beyond the political domain, we lend support to the psychological perspective on ideology. It is important to recognize that liberals and conservatives take such different approaches to similar problems in society not only because of loyalty to their preferred parties and their positions on political issues, but also because of different psychological needs that may ultimately manifest in different political attitudes. Furthermore, the topics of discussion used in the

current study were highly relevant to the individuals in the sample, rather than arbitrary. Personally relevant topics involve more cognitive elaboration and lead to more cognitive certainty than do personally irrelevant topics, making it more difficult to create attitude change. Our predictions, therefore, stood up to a very difficult test and the results were replicated across two different samples and two different topics of discussion. Above and beyond their utility in the study of psychology, the current results could also inform political strategists and the makers of public policy. Knowing how to tailor persuasive messages to the psychological tendencies of specific political audiences could have a major impact on how political campaigns and new public initiatives gain support.

Future research should examine the extent to which conservatives and liberals rely on various types of heuristic cues, such as source-relevant cues versus message-relevant cues, in their processing of persuasive messages. The current study

only investigated one type of interpersonal heuristic cue, so examination of other heuristic cues is certainly warranted. Future research should also examine the lifespan of the newly formed opinions that arise when individuals engage in systematic versus heuristic processing. It would be interesting to learn whether differences exist in the longevity of the persuasion induced in conservatives as compared to the persuasion induced in liberals. Finally, although the current study employed topics of discussion that have been well established in the body of literature on persuasion, future studies might use a wider variety of topics—perhaps issues that are personally relevant to conservatives, and which might lead conservatives to process them more systematically. Until then, it will suffice to know that political ideology plays an important role in our everyday lives, particularly in the realm of information processing, and that it is a subject worthy of the sustained attention of research in psychology. ■

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Romantic Relationship Characteristics and Offending Among Post-Incarcerated Females

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Current research lacks a comprehensive picture of romantic relationships in female adolescents reentering the community post-incarceration. There is also very little empirical research examining the influence of romantic relationship factors on persistence and desistance from antisocial behavior among females incarcerated during adolescence. This study examined the influence of four romantic relationship factors—partners' delinquent behavior, partners' acceptance of girls' antisocial behavior, relationship violence (both perpetrated by participants toward their partners and by partners toward participants), and relationship caring—on self-reported delinquent and violent offending. Female participants (n = 102) were interviewed at least six months after incarceration. Significant associations were found for partner delinquency and relationship caring on delinquent offending and for partner delinquency on violent offending.

Introduction

Although males commit more crimes overall than females, crime rates among females continue to increase even while crime rates among males decrease (Trulson, Marquart, Mullings, & Caeti, 2005; Snyder, 2004; Goldweber, Broidy, & Cauffman, 2009). Between 1980 and 2006 the rate of juvenile female arrests for aggravated and simple assault grew at a rate over double that of juvenile males, and the percentage of juvenile arrests for violent crimes decreased by only 12% for females while that of males decreased by 22% (Snyder, 2008). Despite these trends, we know very little about the developmental trajectories of young female juvenile offenders (Giordano, Cernkovich, & Rodolph, 2002).

For many youth, the transition out of the juvenile justice system coincides with the transition into adulthood roles and responsibilities. Rhule-Loue and McMahon (2007) have suggested that life-functioning domains important to adolescents' transitions to adulthood may serve as "turning points" in development, helping to promote positive adjustment, especially for individuals with chronic histories of antisocial involvement. One such domain, in light of its growing prevalence and significance during late adolescence and early adulthood, may be that of healthy romantic relationships (Collins, Welsh, & Furman, 2009). Yet, a study by Leverentz (2006) exploring the impact of romantic relationships on the reentry experiences of adult female ex-offenders emphasizes the lack of research on this population, especially in comparison to male ex-offenders (Laub & Sampson, 1993). There is even less research on juvenile female ex-offenders.

The existing research, however scant, suggests that knowledge of romantic relationship influences may be especially important in understanding reentry outcomes of post-incarcerated females, particularly during emerging adulthood. In a review of the literature on antisocial behavior among girls, Odgers and Moretti (2002) found that relationships with family, friends, and significant others might account for involvement in delinquent and aggressive behavior more among girls than among boys. Indeed, romantic partner deviance has been reported as having a stronger effect on female than on male involvement in minor deviance (Haynie, Giordano, Manning, & Longmore, 2005). By understanding the nature of post-incarcerated female adolescents' relationships and their influence on desistance from offending, we can better aid this population in reentrance and readjustment to the community. Therefore, in the current study we investigated the nature of romantic relationships among post-incarcerated female delinquents transitioning into adulthood. We also examined the association between specific romantic relationship characteristics and desistance from antisocial behavior.

Background

Reaching a better understanding of the nature of post-incarcerated female adolescents' romantic relationships, and their potential influence on desistance from offending, first requires a discussion of the likelihood of continued offending among girls transitioning into adulthood. Also important is a general understanding of why studies of romantic

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relationship influences on behavior change stress the importance of looking at adolescent romantic relationships, in addition to adult relationships, and at desistance from delinquent behavior, specifically. Finally, it should be highlighted that such research has found that it is not the mere presence or absence of a romantic relationship that accounts for possible associations between romantic relationships and desistance, but rather, that these associations may instead be better explained by specific relationship characteristics. Among such characteristics are partner delinquency, partner acceptance of antisocial behavior, romantic relationship violence, and relationship caring. We discuss the following in greater depth below, followed by an overview of the current study.

Desistance Among Female Juvenile Offenders: Are They Likely to be Life-Course Persistent?

It has long been accepted in criminology that crime rates peak in late adolescence and early adulthood, followed by a sharp drop thereafter (Gottfredson & Hirschi, 1983; Griffin, 2006). Life-course offenders, or delinquent youth who persist in offending as adults, consist almost entirely of males (Moffitt, 1993a). Although not all studies report disparities in rates of male versus female life-course offending as large as Moffitt (1993a), most studies examining chronic offending among boys and girls find much lower rates of chronic offending for female than for male adults. Female delinquency also appears to end more abruptly than male delinquency (Goldweber et al., 2009). This suggests widespread desistance from offending by females during emerging adulthood. Yet, once female adolescents become involved in offending, less is known about their transitions to adulthood and how they adapt post incarceration (Broidy & Cauffman, 2006). Female offenders' tendencies towards desistance, as well as recent boosts in female criminality, have generated calls within the field to increase research on female offending and desistance from offending (see e.g., Piquero, Brame, Mazerolle, & Haapanen, 2002; King, Massoglia, & Macmillan, 2007).

Why Study Romantic Relationships Among Female Offending Youth?

There are several reasons to study romantic relationships among female offenders transitioning to adulthood. White, Bates, and Buyske (2001) posited that social and environmental characteristics beyond adolescence may in fact explain persistence of delinquency from adolescence to adulthood better than childhood factors. Also, Laub and Sampson (1993) suggested that adult social bonds may lead to desistance from crime. However, past studies of adolescent behavior tended to focus primarily on the roles played by family and friend relationships in adolescent behavior and development. Only in the last decade has research delved into an investigation of romantic relationship influences on adolescents (Collins et al., 2009). Such investigations have highlighted interdependencies between family and friend relationships and romantic relationships, as well as the unique influence of romantic relationships on development and desistance from crime (Cauffman, Farruggia, & Goldweber, 2008; Meeus, Branje, & Overbeek, 2004; Warr, 1998).

Initial Studies of Romantic Relationship Influences on Behavior Change

In the past, research emphasizing the influence of romantic relationships on desistance from offending primarily looked at marriage among males (Sampson & Laub, 1990). Sampson and Laub's well-known theory on adult social bonds and their influence on behavior was derived from a longitudinal study of 500 male ex-offenders. They posited that strong marital attachment bonds may lead to positive behavioral change. This theory has become known as "the good marriage effect" and has led to a surge of research on marital effects. Recent studies, however, have highlighted certain limitations of Sampson and Laub (1990) and Laub, Nagin, and Sampson (1998). It is unclear whether their findings effectively capture the experiences of female delinquents (Giordano et al., 2002), especially during adolescence. For instance, while both male and female adolescent delinquency is associated

with peer involvement, females committing delinquent acts are more likely to be in mixed-gender groups, whereas males usually participate in delinquency with same-gendered peers (Giordano et al., 2002). Recently, King et al. (2007) reported different effects of romantic relationships on male versus female offending in early adulthood. Specifically, they suggested that marriage may be less important for female than for male desistance. However, this is surprising in light of Odgers and Moretti's (2002) finding that relationships, in general, relate to delinquency more in girls than boys, and Giordano et al.'s (2002) suggestion that marital attachment, if significant, might serve as an even more important influence on women's than on men's desistance. Clearly, more research is needed to understand what underlies such contradictions.

Initially, studies of romantic relationship influences on behavior tended to focus on the presence or absence of quality bonds with wives (see e.g., Horney, Julie, Osgood, & Marshall, 1995; Laub et al., 1998; Laub & Sampson, 2003; Sampson & Laub, 1993; Warr, 1998). Of late, other romantic relationship types are being included in the study of romantic relationship predictors of offending. This is significant because the effect of marriage on offending has been shown to differ from that of other romantic relationship types (Leverentz, 2006). Male offenders appear to be differentially impacted by cohabitation with a non-marital partner versus a spouse. Horney et al. (1995) reported that while living with a wife may decrease offending among male offenders, living with a girlfriend increases offending. In contrast, Sampson, Laub, and Wimer (2006) found that cohabitation with a non-marital romantic partner does relate to lower crime involvement in a sample of men, albeit not as strongly as marriage. After conducting a 1-year study on women offenders recently re-entering the community from incarceration, Leverentz (2006) emphasizes the need to look at different types of romantic relationships when considering their influence on offending behavior. Finally, while adolescent relationships are far less likely to include marriage, growing evidence suggests that

they significantly impact individual adjustment and development (Collins et al., 2009) and should be further explored.

Developmental Significance in Transitioning to Adulthood

Until recently the developmental significance of adolescent romantic relationships was largely ignored. According to Collins (2003, p. 8), "Now that the norm for young people in the US and other Western cultures is a succession of premarital romantic relationships... it is important to examine the potential developmental advantages of these experiences, as well as their detrimental effects."

Also, romantic relationships in adolescence play a different role in development, but one just as significant as friend and family relationships. Furman and Shomaker's (2008) findings show that adolescent romantic relationships are characterized by distinct patterns of interaction that differ from adolescents' relationships with both their mothers and friends on multiple dimensions. Moreover, adolescents sometimes report spending more time with romantic partners than with parents or friends (Laursen & Williams, 1997). They also experience a heightened emotionality in romantic relationships that is absent in same-gendered friendships (Giordano, Manning, & Longmore, 2005). In light of these findings, there has been a major surge in the study of adolescent romantic relationships over the last decade. The focus of such studies has shifted from looking at descriptives to relationship characteristics and their potential impact on individuals (Collins et al., 2009). Collins et al. (2009) further notes an increase in large-sample longitudinal studies and the use of detailed interviews, both of which characterize the current study.

Still, little is known about how the developmental significance of romantic relationships during emerging adulthood or the transition to adulthood compares to that of adolescence and adulthood (van Dulman, Goncy, Haydon, & Collins, 2007). It may be that the role of romantic relationships is distinct in emerging adulthood from that of early

or mid-adolescence (van Dulman et al., 2007). We do know that over the course of adolescence, romantic relationships become increasingly more prevalent. In a study by Carver, Joyner, and Udry (2003), 70% of adolescent participants at age 17 reported having had a “special” romantic relationship in the past 18 months, up from 36% at age 13. Connolly and McIsaac (2008) reported that termination of romantic relationships becomes less frequent by late adolescence. Also, while Jouriles, McDonald, Garrido, Rosenfield, and Brown (2005) show the relationship between adolescent romantic relationship qualities and behavior may be negative (adolescents report rates of physical aggression in dating relationships ranging from 10% to as high as 48%), romantic relationships in emerging adulthood are associated with a decline in offending behavior (Farrington, 1995), shifting from a potential risk factor to a possible protective factor (Zimmer-Gembeck, Siebenbruner, & Collins, 2001). Therefore, researchers have begun to emphasize the role of romantic relationships on desistance from antisocial behavior for youth transitioning to adulthood (Simons, Stewart, Gordon, Conger, & Elder, 2002).

Romantic Relationship Characteristics and Links to Desistance

A key question is what helps account for the role of romantic relationships on desistance during this period of developmental transition. Recent findings showing increases in romantic relationship frequency and length suggest that specific romantic relationship characteristics may be changing during the transition to adulthood, and that they may partly account for the changing role of romantic relationships on offending behavior during this period. Preliminary studies of romantic relationship influences on delinquency primarily compared the existence versus the absence of romantic relationships as a link to desistance (Sampson & Laub, 1990). Results from further research, however, have indicated that merely having a spouse or intimate partner does not influence delinquency (Laub et al., 1998; Meeus et al., 2004). These findings

demonstrate that while romantic relationships can contribute to desistance from offending, their influence is contingent upon specific relationship characteristics as opposed to the mere existence or absence of a romantic relationship.

For example, Laub and Sampson (2003) link positive quality relationships to desistance from crime for some male offenders. Woodward, Fergusson, and Horwood (2002) found that involvement with a non-deviant partner was associated with less offending at age 21 than having no partner; in contrast, having no partner was associated with less offending than having a deviant partner. Partner deviance, then, is one characteristic of romantic relationships that has been studied in an effort to better understand desistance from offending. Additionally, romantic relationship characteristics have been found to be associated with girls’ delinquency where general partner characteristics such as age were not (Cauffman et al., 2008). Such findings support further inquiry into associations between specific romantic relationship characteristics and offending, or desistance from offending among post-incarcerated females transitioning to adulthood.

Partner Delinquency

In a sample of post-incarcerated females, Cauffman and Broidy (2006) found that those who desisted from crime were not only significantly more likely to be married (54% vs. 34.4%) than non-desisters, but also more likely to have conventional spouses (i.e., husbands reported as having a steady job and no arrest history) (24.2% vs. 5.0%). This coincides with recent research suggesting that associations with deviant male partners often draw women into criminal offending (Alarid et al., 2000; Hanyie, 2001). Haynie et al. (2005) drew similar conclusions for adolescent relationships. For already delinquent adolescent females, selection of antisocial partners during the transition to adulthood appears to promote persistence of antisocial behavior in adulthood (Moffitt, Caspi, Rutter, & Silva, 2001). Woodward et al. (2002) found that adolescent

offenders who become romantically involved with delinquent (compared to non-delinquent) partners in early adulthood are more likely to continue offending. Similarly, Moffitt et al. (2001) found that only girls with antisocial boyfriends persisted in offending by age 21. In effect, it may be that for already delinquent adolescent females, the selection of pro-social or non-delinquent partners during the transition to adulthood promotes desistance from antisocial behavior.

Partner Acceptance of Antisocial Behavior

Both antisocial males and females report sanctioning antisocial behavior by their partners (Moffitt et al., 2001). This may have a negative influence on desistance from offending. For example, in one investigation, girls involved in delinquency were more likely than those who were not to experience high levels of antisocial encouragement by romantic partners (Cauffman et al., 2008). Although little research exists on the influence of partner acceptance of antisocial behavior on offending among post-incarcerated girls transitioning to adulthood, these findings suggest a potentially significant and negative influence on desistance that should be further explored.

Romantic Relationship Violence

Well-documented reports of violence against a partner show similar if not higher rates of violence perpetrated by females compared to males (Linder, Crick, & Collins, 2002); although this does not mean that the degree of resulting harm or injury is necessarily equal, it is important to look at relationship violence perpetrated by both partners when examining the influence of partner violence on offending. The little research that exists on partner violence and its influence on delinquent (non-violent) and violent offending does suggest a relationship between them (Moffitt & Caspi, 1999). Both perpetration of violence towards romantic partners and victimization by romantic partners, or the experience of violence perpetrated onto oneself by a romantic partner, have been found to occur

more frequently among previously institutionalized young adults than those who have never been institutionalized (Lanctôt, Cernkovich, & Giordano, 2007). Therefore, it may be especially important to investigate the influence of partner violence on offending in post-incarcerated adolescents transitioning to adulthood.

Relationship Caring

Adolescent relationship quality, or the level of perceived intimacy, affection, and nurturance by partners, has been found to relate to both positive and negative outcomes (Furman & Collins, 2008). Higher levels of partner support predicted lower levels of criminality in both adolescents and adults (Meeus et al., 2004); in a study of post-incarcerated females, desisters reported significantly higher marital quality than non-desisters (Cauffman & Broidy, 2006). While van Dulmen, Goncy, Haydon, and Collins (2007) report similar findings in relation to the positive influence of romantic relationship security, they draw a distinction between its influence during adolescence and emerging adulthood. Specifically, romantic relationship security served as a protective factor for externalizing problems more so in emerging adulthood than in adolescence.

Relationship caring may have particularly important implications for previously incarcerated female adolescents reentering the community. In a longitudinal study involving males and females institutionalized during adolescence, previously institutionalized participants reported less caring and trust from intimate partners during adulthood. Furthermore, previously institutionalized females reported less caring and trust from intimate partners than previously institutionalized males (Lanctôt et al., 2007). However, little is known about the specific influence of romantic relationship caring on offending behavior among female adolescents recently released from incarceration.

Overview of the Current Study

The current study is a response to the lack of knowledge on (a) the nature of romantic

relationships among adolescents transitioning to adulthood, especially previously incarcerated females, and (b) the influence of specific romantic relationship characteristics on offending in this population. To address these gaps we examine the frequencies at which specific romantic relationship characteristics occur among our participants.

Specifically, we investigated the influence of four romantic relationship factors on self-reported delinquent and violent behaviors among formerly incarcerated females: (1) partners' delinquent behavior, (2) romantic partners' acceptance of the girls' antisocial behavior, (3) relationship violence (both perpetrated by participants toward their partners and by partners toward participants), and (4) relationship caring. In line with past research findings, we hypothesized that positive relationship outcomes would be associated with desistance from crime (e.g., Woodward et al., 2002; Cauffman et al., 2008; Moffitt & Caspi, 1999; Cauffman & Broidy, 2006). Specifically, girls who reported lower levels of romantic partners' acceptance of and involvement in delinquent behavior, less relationship violence, and more relationship caring would be less likely to report involvement in delinquent and serious crimes.

Method

These analyses are based on data collected in Wave 2 (w-2) of the University of Virginia Gender and Aggression Project, a longitudinal study of female aggression currently in its third wave (w-3) of data collection. Participants were first interviewed (Wave 1; w-1) when they were incarcerated in a Virginia juvenile correctional facility. Ninety-three percent of girls incarcerated over a 14-month period participated, $n = 141$. At w-2, 102 of these participants participated in a follow up interview after they had been released from incarceration for at least six months. Participants completed 22-hour interviews consisting of an in-home assessment administered by trained graduate interviewers. Only these w-2 data are analyzed in the current

study, which was approved by the University Institutional Review Board.

Participants

Data were collected from 102 late adolescent females who had been released from secure custody for a minimum of 6 months ($M = 20.86$, $SD = 8.36$). Their mean age was 18.85 ($SD = 1.53$) years, and most identified themselves as African American (49.9%) or Caucasian (42.1%). Participants provided written consent.

Measures

Delinquent and Violent Offending

Participation in delinquent and violent activities was assessed via the Self Report of Offending (SRO-R; Elliott & Huizinga, 1989), a 15-item measure modified for the current study. Participants were asked if they had engaged in (yes/no) six types of delinquent acts and six types of violent acts since being released from custody. Responses were summed for analyses.

Partners' Delinquency and

Acceptance of Girls' Antisocial Behavior

The Denver Youth Study (DYS-R; Dahlbert, Toal, Swahn, & Behrens, 2005) is divided into two parts. The first part is a six-item measure assessing participants' knowledge of their romantic partners' involvement in delinquent behaviors, asking how many of participants' partner(s) (0 = none of them; 3 = most of them) engaged in these activities since their release from incarceration. The second part asks how participants' romantic partners would react to knowledge of their antisocial behavior (0 = would not care at all; 3 = would be very upset with me).

Relationship Quality

The Friendship Quality Questionnaire (FQQ; Parker & Asher, 1993) is an adolescent report of friendship adjustment and peer acceptance, modified for use with romantic partners. Only questions from the Validation and Caring scale were used. Participants

rated 10 items designed to assess the level of caring and validation in their romantic relationships ($\alpha = .85$). Items were scored on a 5-point Likert scale from 1 (not at all true) to 5 (really true).

Relationship Violence

The Conflict Tactics Scale (CTS; Straus, 1979) assesses violence and aggression within relationships. The CTS was modified (CTS-R; Pepler & Craig, 1998) to include indices of verbal and physical forms of aggression both perpetrated and experienced within family, peer, and romantic relationships. Participants reported their involvement ($\alpha = .87$) and experience ($\alpha = .84$) with a subset of four of these items within the 6 months prior to their interview. Responses were recorded on a 4-point scale ranging from 1 (never) to 4 (always).

Results

The study's first purpose was to better understand the prevalence of certain romantic relationship characteristics among females recently released from incarceration and readjusting to the community during emerging adulthood. On average, participants reported high levels of caring and validation ($M = 4.28$, $SD = .65$) in their romantic relationships. In general, participants reported low levels of violence towards partner(s) ($M = 1.56$, $SD = .63$) and also low levels of violence toward themselves, perpetrated by their partner(s) ($M = 1.40$, $SD = .57$). They also reported low levels of romantic partner delinquency ($M = .89$, $SD = .78$) and romantic partner acceptance of antisocial behaviors ($M = 2.31$, $SD = .80$). Scores for total self-reported offending ($M = 1.61$, $SD = 2.05$), as well as violent ($M = .93$, $SD = 1.16$) and delinquent ($M = .59$, $SD = 1.10$) offending, were also obtained.

Overall, 61.8% of girls reported some level of offending, while 38.7% of participants reported desisting from offending or having not endorsed at least one SRO item. To investigate the influence of romantic relationship factors on self-reported delinquent and violent offending, we performed

regression analyses predicting offending from romantic relationship factors. Table 1 (next page) reveals that romantic partners' acceptance of antisocial behavior, violence toward a romantic partner, or victimization by a romantic partner were not concurrently related to participants' engagement in delinquent activities. However, partners' delinquent behavior and relationship caring were significantly related to participants' involvement in delinquent activities. As predicted, lower levels of partners' delinquent behavior and higher levels of relationship caring were associated with less delinquent activity.

Analyses also revealed no significant relationships between romantic partners' acceptance of antisocial behavior, violence toward a romantic partner, victimization by a romantic partner, or relationship caring, and participants' involvement in violent activities. However, romantic partners' delinquent behavior was significantly related to participants' involvement in violent activities. As predicted, higher levels of partners' delinquent behavior were significantly related to more violent offending.

Discussion

Our first goal was to examine the nature of romantic relationships of previously incarcerated females as they transition to adulthood. Overall, participants reported higher levels of positive romantic relationship characteristics in their relationships and lower levels of negative characteristics. This is promising in light of research suggesting populations of antisocial and ex-offending adolescent females are more likely than males and non-delinquent females to suffer from poor relationship outcomes and to experience recidivism associated with partner choices (Moffitt et al., 2001; Simons et al., 2002).

We further investigated whether specific romantic relationship features related to desistance from delinquent and violent offending. Results revealed that partners' delinquency was

Table 1

Relationships between Romantic Relationship Factors and Type of Reoffending

* p < .05

** p < .01

*** p < .001

SRO = Self Report of Offending

RP = Romantic Partner

	SRO Total	SRO Delinquent	SRO Violent
	B (SE)	B (SE)	B (SE)
RP Delinquent Behavior	1.17 (.26)***	0.52 (0.14)***	0.40 (0.16)**
RP Acceptance of Anti-Social Behavior	-0.15 (0.25)	-0.23 (0.14)	0.06 (0.15)
Violence Toward RP	-0.30 (0.36)	-0.26 (0.19)	-0.01 (0.21)
Violence by RP	0.72 (0.41)	0.25 (0.220)	0.46 (0.25)
Caring and Validation	0.46 (0.33)	0.36 (0.17)*	0.00 (0.20)
R ²	0.25	0.26	0.16

more strongly related to violent and delinquent offending than other relationship characteristics. Perhaps girls with partners who partake in delinquent and violent activities may be especially negatively influenced by their romantic relationships and less likely to desist from offending. A second factor, relationship caring, was significantly inversely related to delinquent, but not violent, offending among participants. Also, victimization by a romantic partner related marginally to violent offending behavior. Overall, these findings support our hypothesis that specific romantic relationship characteristics may be associated with post-incarcerated females' offending trajectories during the transition to adulthood. Knowledge of these potential associations and offending trajectories among this population is not only important for finding ways to improve girls' chances of desisting from offending as they transition to adulthood, but also for thereby fostering success in other life domains (e.g., work, family) often hindered by continued offending. Our findings are in line with and support existing research on the association between romantic relationships and desistance from offending. Significant findings were attained

for those romantic relationship characteristics (i.e., partner delinquency and caring) most explored and most linked to criminal offending by previous research (e.g., Moffitt et al., 2001; Alarid et al., 2000; Hanyie, 2001; Haynie et al., 2005). In contrast, non-significant and marginally significant findings were found for romantic relationship characteristics that have previously been less explored (i.e., relationship violence and victimization, and partner acceptance of antisocial behavior). These should be further studied, especially among our specific population of participants, with the data from W-3.

Strengths and Limitations

Caution must be taken not to draw causal conclusions from these results. It is possible that significant findings reflect offending and non-offending participants' choices to enter into romantic relationships marked by specific qualities, rather than a direct effect of romantic relationship factors on the likelihood of offending (Cauffman et al., 2008). In other words, our findings of significant romantic relationship associations with offending cannot be conclusively said to cause offending or desistance from offending among participants.

Nevertheless, this study builds directly on current knowledge of the nature of romantic relationships and its link to desistance among post-incarcerated females during emerging adulthood. Cernkovich, Lanctôt, and Giordano (2008) comment, “Studies identifying the mechanisms underlying the causes and consequences of antisocial behavior among female delinquents as they transit to adulthood are scarce and have important limitations: most are based on official statistics, they typically are restricted to normative samples, and rarely do they gather prospective data from samples of high-risk females” (p. 3). The current study addresses all of these limitations.

Whereas most research on the effects of romantic relationships on offending has looked primarily at adults or mid-adolescents, we were specifically interested in the transition to adulthood. Also, rather than focus on the link between romantic relationship factors and the frequency of offending in general (Woodward et al., 2002), we examined both violent and delinquent offending. Nor did we limit our analysis to a specific romantic relationship type; instead participants reported on experiences with any and all partners with whom they perceived themselves as being in a romantic relationship. This study built on previous research by looking at a variety of romantic relationship factors, most of which have not been included in studies on this particular population of female delinquents.

One potential limitation is that we did not examine any interactions among family, friend, and romantic relationship factors, but rather focused exclusively on the latter. Inclusion of all three enmeshment networks may help paint a more complete portrait of protective versus hindering factors on desistance from offending among adolescents (Lonardo, Giordano, Longmore, & Manning, 2004). Also, our results might reflect certain confounding variables not controlled for, such as length of romantic relationships, number of romantic partners, romantic partners’ frequency and type of offending, and the timing of partnership formation in relation to incarceration and release (Woodward et al., 2002;

Broidy & Cauffman, 2006). These may have had an effect on some of the variance in offending accounted for by our romantic relationship factors.

Additionally, our design did not control for biased responses by participants to questions relating to their romantic relationships and partners by obtaining partner interviews (Haynie et al., 2005). This limitation may be especially pertinent to our population of participants, as it is unclear whether female ex-offenders transitioning to adulthood are more or less likely than other age groups to exaggerate or withhold reports of offending or romantic relationship features (Connolly, Craig, Goldberg, & Pepler, 1999). On the other hand, the use of self-report methodology may have encouraged more honest disclosure by participants who were informed of our federal certificate of confidentiality, which guaranteed no risk of prosecution for responses as long as no mention of a future intent to harm another person was made. Moffitt and Caspi’s (1999) findings that emphasize the high percentage (70-80%) of agreement between partner self-reports of physical violence in romantic relationships at age 21 provides support for this assumption.

Real-World Implications

By exploring potential predictors of desistance from offending among previously incarcerated females transitioning to adulthood, we revealed several findings with important implications for better intervention, secondary prevention, and ways to promote desistance among female offenders. Our results highlight the potential importance of partner delinquency and romantic relationship quality as an influence on offending among female offenders transitioning to adulthood. These and similar factors may play an increasingly important role in the lives of this population of juvenile offenders: they not only have to re-adjust to their communities after leaving the juvenile justice system, but do so at a time when they are beginning to take on adult roles and responsibilities. Allotting more attention to romantic relationship factors may contribute to the development of new

and better-informed treatment plans for this population of girls. For example, our particular findings suggest that efforts to encourage high quality romantic relationships and positive partner choices among post-incarcerated adolescent females may contribute to increased desistance among our population of participants. Doing so may also result in higher success rates of already popular interventions such as Multi-Systemic Therapy (MST), which appear to be promising as well as cost-effective in the rehabilitation of juvenile delinquents (Gibbons, 1999). These programs provide intensive treatment within youths' families and communities and among multiple systems (e.g., peers, school, and neighborhood), but they may benefit even more from increased attention toward adolescent romantic relationships.

Increasing desistance among female juvenile delinquents, thereby reducing chronic offending into adulthood, will inevitably reduce individual and financial costs of crime. After accounting for the financial costs associated with crime and the criminal justice system (e.g., incarceration), any single offender's continued offending will cost society approximately one million dollars over the offender's lifetime. Among male juvenile offenders, for example, external costs of offending between ages 14 and 17 impose around \$83,000-\$335,000 in external costs, as well as about \$15,000 to \$62,000 in annual victim costs. While the costs of chronic juvenile crime are shockingly high, they may be reduced through increased research and efforts to promote desistance among at-risk populations transitioning to adulthood, when over 30% of crimes are committed (Cohen, 1998).

Recent attention has also been given to the increased resources being dedicated to adult female offenders and their dependent children (Lester, 2006). Children of incarcerated females are six times more likely to be incarcerated than children whose mothers were not incarcerated (Johnston, 1996). By providing information about female juvenile offenders and factors associated with their desistance from offending, our results could help

reduce such costs if applied towards improving interventions; increasing girls' rehabilitation during emerging adulthood, thereby preventing the continuation of offending in adulthood, would reduce crime in subsequent generations. In addition, personal costs to antisocial girls, who have been shown to experience more negative adult outcomes, including higher mortality rates, a 10-to 40-fold increase in criminality rates, and multiple service use, may be reduced as well (Pajer, 1998).

Future Directions

Future research should further explore the relationship between victimization by romantic partners and offending among females previously incarcerated as adolescents, which we found to be marginally related. Particular attention should be given to the link between partner delinquency and offending, as this was the relationship characteristic associated with both types of offending. Building upon our findings, the influence of partners' delinquent versus violent offending should be studied. Additionally, looking at effects of length, number, and type (i.e., marriage, dating) of romantic relationships, as well as girls' prior offending, will provide a more complete picture of the link between romantic relationships and offending among these high-risk adolescents (e.g., Laub et al., 1998). Since adolescents and emerging adults are in the initial stages of romantic exploration, romantic experiences independent of romantic relationships should be explored as well (Collins et al., 2009).

Furthermore, we already know the positive influence of marriage on delinquent males has been found to be cumulative over time (Laub et al., 1998), and the romantic relationships of female ex-offenders can be both positive and destructive at different points in time (Leverentz, 2006). These findings may or may not carry over to our population of participants. Therefore, comparisons of short-term and long-term effects of romantic relationships are needed. The current analyses were generated using data from the study's second wave (w-2) of data collection; the Gender and Aggression Project is

now in its third wave and seeks to obtain a more extensive view of participants' offending trajectories post-incarceration.

Concluding Remarks

This study revealed that partners' delinquency was more predictive of self-reported offending than any other romantic relationship factor analyzed. Such a finding can be a particular source of concern for at-risk girls reentering the community after incarceration because they generally return to communities with large proportions of male ex-offenders (Leverentz, 2006). At the same time, the fact that girls' romantic relationship experiences were described as generally positive is promising. By revealing potentially significant associations between positive romantic relationship characteristics and desistance from offending, our findings

suggest important and optimistic implications for better programs promoting prosocial transitions into adulthood for previously incarcerated girls. In turn, if such programs prove successful, greater desistance from crime might promote positive outcomes across other important life domains like physical and mental health (Pajer, 1998). Further research on the nature of romantic relationships and their influences is especially necessary among high-risk females, and should help to determine appropriate target areas for prevention and intervention. In sum, by better understanding late adolescent offending trajectories in females, more effective strategies to foster prosocial community reentry after release from incarceration can be developed to promote smoother and healthier community readjustment. ■

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Attentional Asymmetry Between Blacks and Whites for Ingroup and Outgroup Faces

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In the present experiment, we examined whether Blacks and Whites differed in their automatic allocation of attention to ingroup versus outgroup faces. The rapid serial visual presentation paradigm (Raymond, Shapiro, & Arnell, 1992) was employed to measure participants' ability to disengage from ingroup and outgroup faces. We hypothesized that Black participants would perform significantly worse at disengaging from faces than White participants because they, as members of the minority group, are more attentive to racial identity-relevant information. Our data show that ingroup (Black), traditional outgroup (White) and non-traditional outgroup (Asian-Indian) faces all held the attention of Black participants significantly more than that of White participants. Such a finding supports the idea that Blacks attend to faces more than Whites, and that this process occurs at the automatic level.

Introduction

When one is the sole woman around a poker table, or the sole Black person at a polo game, one's awareness of one's minority status becomes heightened. This increase in awareness renders the minority experience distinct from the majority experience. In the United States, the traditional majority group is White, and the traditional minority group is Black. Despite significant gains for Blacks generated by the civil rights movement in the last century, evidence shows that there are still serious disparities between these groups, including the well-documented gaps between Blacks and Whites in educational achievement (National Center for Education Statistics, 2001; U.S. Department of Education, 2002), income levels (Altonji & Doraszelski, 2005; U.S. Bureau of the Census, 1996), and wealth (Keister, 2000; Blau & Graham, 1990; Oliver & Shapiro, 1997).

Against the backdrop of these inequalities, recent research on social identity threat (e.g., Steel, Spencer, & Aronson, 2002; Kaiser, Vick, & Major, 2006; Spencer, Steel, & Quinn, 1999) and social identity contingencies (Purdie-Vaughns, Steele, Davies, Dittmann, & Crosby, 2008) has shown that the minority experience has led Blacks to be more aware of identity cues and racially relevant information than Whites. To better understand the nature of this asymmetry, the present study tested whether it operates even at the unconscious level by employing the rapid serial visual presentation paradigm (RSVP). This

paradigm measures how salient particular types of stimuli are to participants at the level of automatic perception. We hypothesized that Blacks would find faces (encoded with racial information) more salient than Whites.

Social Identity Threat

Stigmatization, the activation of negative group stereotypes, can sometimes lead members of the stigmatized group to feel threatened on account of their social identity (Major & O'Brien, 2005). This threat occurs because members of stigmatized groups are aware of the cultural stereotypes members of the dominant group hold against them (Crocker, 1999; Crocker, Steele, & Major 1998; Steele, 1997). This knowledge is learned from a young age (McKown & Weinstein, 2003), which means that from very early on, members of stigmatized groups "develop belief systems about being devalued" and "these expectations cause them to become especially alert or vigilant for signs of devaluation" (Kaiser et al., 2005, p.332). When people feel their identity is threatened, they may automatically focus their attention on threat-related stimuli to determine how to respond (Pratto & John, 1990). For instance, in one study, female participants who expected to interact with a sexist man allocated more attention to subliminal cues that threatened their female identity (Kaiser et al., 2006). More stigma-conscious women were also found to be more vigilant for subliminally

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presented identity-threatening words (Kaiser et al., 2006). Similarly, race is a common source of identity threat for minorities; thus they are likely to be more attentive to racial identity-relevant information in threatening situations. In contrast, majority members rarely experience identity threat and thus are not likely to attend to cues related to their identity. This can lead to an attentional asymmetry between minority and majority members, where minority members attend to identity-relevant cues that majority members do not.

Social Identity Contingencies

Another potential source of attentional asymmetry for minority groups concerns cues that trigger social identity contingencies, “the range of vulnerabilities and opportunities people expect to face based on the settings’ response to one or more of their social identities” (Purdie-Vaughns et al., 2008, p. 616). Cues to social identity contingencies include judgments, stereotypes, opportunities, restrictions, and treatments (Steele et al., 2002). Purdie-Vaughns et al. (2008) found that Black professionals were attuned to institutions’ minority representation and diversity philosophy—that is, they paid attention to the number of minority members in a firm and whether that firm sent an explicit message of valuing diversity. They believed that the firms’ hiring decisions and judgments on the value of diversity affected their vulnerabilities and opportunities with the firms, reporting mistrust of institutions with combined low minority representation and “colorblindness” instead of “valuing diversity” philosophies. They felt threatened by the social identity contingencies of work environments with those features.

A similar study was run with White participants, but found that Whites’ trust and comfort were not affected by an institution’s minority representation or diversity philosophies (Purdie-Vaughns, 2004). This asymmetry supports the idea that only “people at risk of devaluation based on group membership are attuned to cues that signal social identity contingencies” (Purdie Vaughns et al., 2008, p.

615). These racial and identity cues—minority representation and diversity philosophy—are less salient to majority members, but critical for minority members who find in them valuable information for how to maximize their opportunities in the given environment.

Present Research

The two lines of research described above have clearly shown that members of the racial minority group are more attentive to racial cues. However, these cues are represented as being processed at the conscious level. If Whites are less aware of identity information than Blacks, could this difference be captured at an automatic level as well? To the authors’ knowledge, the present research explores for the first time whether the cognitive processes that facilitate attentional asymmetries between Blacks and Whites operate automatically without conscious control.

Attentional Blink

To examine Blacks’ and Whites’ automatic attention to racial information, we relied on the attentional blink phenomenon. Attentional blink refers to the impaired processing of a second visual stimulus presented immediately after an initial stimulus, due to “temporal or capacity limitation on attention” (Ryu & Chaudhuri, 2007, p. 1057). Simply stated, if a stimulus presented at Time 1 (T_1) captures a participant’s attention, the participant will be less likely to perceive a second stimulus presented immediately after at Time 2 (T_2). The duration of attentional blink can be measured using the rapid serial visual presentation paradigm (RSVP) (Raymond, Shapiro, & Arnell, 1992), a method of displaying text or images in which each piece of information is shown briefly in sequential order.

Early attentional blink studies were interested in how much of the second stimulus is processed before participants “blink” (e.g., Chun & Potter, 1995; Luck, Vogel, & Shapiro, 1996; Maki, Frigen, & Paulson, 1997). The significance of the attentional blink paradigm then was whether attention was necessary

for consciousness, drawing on participants' level of awareness of T2 as a proxy. More recent RSVP studies have displayed complex images to investigate other aspects of attention, from the effect of emotional stimuli on attention (e.g., Anderson, 2005) to phobics' unique ability to overcome attentional blink for phobic-relevant information (e.g., de Jong & Martens, 2006; Cisler, Ries, & Widner, 2007). These new lines of research extend the traditional role of the attentional blink paradigm to the study of other aspects of attention. However, to our knowledge, no prior research has capitalized on the attentional blink paradigm's potential to inform how automatic attentional biases of racial- and identity-relevant information may operate, or differ between groups. The RSVP paradigm was thus chosen for its capacity to examine people's automatic attentional allocation to racial information.

In summary, to build on research showing that Blacks and Whites differ in how much they focus on racial identity-relevant information at a conscious level, we hypothesize that they will differ in their attention allocation to racial and identity information at an unconscious level as well. Specially, we predict that Black participants will find it more difficult to disengage from racial information at T1 than White participants and should thus fail to perceive more T2 stimuli, demonstrating a larger attentional blink impairment.

The present study uses faces to exhibit racial information—the sort of identity-relevant “cue” that we predict will induce attentional blink—because of their special potency in encoding race. Bargh, Chen, and Burrows (1996) were able to subliminally prime race with faces that were presented for 13-26 ms; so we expect that faces presented at 100 ms per stimulus, as in our study, will automatically trigger categorization of race as well.

It should be stated that the attentional blink phenomenon has not been reliably demonstrated with faces used as stimuli. Awh et al. (2004) observed an attentional blink effect when both T1 and T2 were faces, but not when T1 was a symbol and T2 was a face. Landau and Bentin (2008) replicated

the Awh et al. (2004) findings, but they also looked at whether there would be an attentional blink when T1 is a face and T2 is an object. In Experiment 2, they found that faces (T1) did not disrupt detection of watches (T2), while in Experiment 4, they found that they did. The difference between the two experiments was the difficulty of the T1 task: Experiment 2 was a detection task (Asian or Caucasian face) and Experiment 4 was a discrimination task (Israeli or Indian face). The authors conclude that “across-categories attentional blink effects when T1 are faces can be obtained in some circumstances but not in others, probably determined by the difficulty of the tasks employed” (Landau & Bentin, 2008).

Marois, Yi, and Chun (2004) designed an RSVP task with faces for T1 and scenes for T2 that was successful in inducing attentional blink; the present study uses this paradigm as well. Despite the occasional immunity of faces to the attentional blink effect, we predict that the RSVP task used in the present study (modeled after Marois, Yi, & Chun, 2004) will be able to induce attentional blink.

In addition to Black and White faces, our research design also includes faces from one non-traditional outgroup, Asian-Indian. Given the research on social identity threat and social identity contingencies showing that Blacks are more sensitive to a wide array of racial cues, we hypothesize that Black participants will pay more attention than Whites to faces of all three races and thereby exhibit larger attentional blink impairment than Whites for all three T1 types.

Method

Participants

Fifty-nine Yale undergraduates (30 females, 29 males) were recruited through the Introduction to Psychology class or through campus postering. Eight were excluded from the final analysis either because they were biracial or because they failed to score above chance on the T2 task. Failure to score above chance suggests that the participants did not complete the task as instructed. Therefore,

51 participants (13 Black females, 12 Black males, 14 White females, 12 White males) were included in the final analysis. Participants were either granted course credit or were compensated \$10 for their time.

Apparatus and Stimulus Materials

The rapid serial visual presentations of the stimuli were performed on a 15.3-inch Dell XPS M1630 at full brightness. All stimuli were presented in color and adjusted to a common resolution of 640×480 px.

The face stimuli (T_1) were collected from the Productive Aging Lab Face Database (Minear & Park, 2004), which coded the faces for neutral expressions. Thirty-nine male faces (13 Blacks, 13 Indians, 13 Whites) between the ages of 18 and 35 were selected, and every effort was made to include only those who did not wear extraordinarily bright or flashy clothing or accessories. Those with red hair or bright-colored eyes were excluded because, as with the flashy apparel, they would “pop out” too much in the streams of photos.

Fifty-six natural scene distractors were selected from Google image searches. We selected only images that did not include humans or signs of human life (e.g., houses, electric and telephone poles, roads) because we wanted to visually and conceptually separate the two categories of stimuli (faces and natural scenes) as much as possible. When presented at T_2 , these natural scene images were rotated 90° to the left or right. To create the rotated natural scenes (T_2), the 56 distractors were randomly divided into the left- and right-orientation groups. The images were then rotated and cropped in Windows Photo Gallery.

Measures and Procedure

Participants were greeted by one of the two experimenters (both Asian male Yale undergraduates) and were told that they were taking part in a study about “whether peoples’ varying levels of interest in video games are correlated with their responses to the [rapidly presented] stimuli.” The participants were told that they would first play a video game simulation that would measure their responses

to the rapid presentations of stimuli, followed by a questionnaire that asked about their level of interest in video games.

Participants were seated in front of the computer and were instructed on how to complete the RSVP task. The task consisted of a series of trials consisting of a stream of 10 stimuli presented at a rate of 100 ms per stimulus. In the stimulus stream, T_1 occupied position 3, 4, or 5 in the RSVP stream and T_2 was placed at lag 1, lag 2, or lag 4. “Lag” refers to the position of T_2 relative to T_1 . Specifically, there was no distractor between T_1 and T_2 at lag 1, there was one distractor between T_1 and T_2 at lag 2, and three distractors between T_1 and T_2 at lag 4. There were 9 types of trials: 3 categories of faces (Black, Indian, and White) × 3 lags (1, 2, or 4). Each type of trial had 30 iterations for a total of 270 trials, presented in a random order.

Participants completed 20 practice trials before beginning the RSVP task. For each trial they were presented with distractor stimuli (natural scenes), followed by T_1 (a face), a variable number of distractors, T_2 (a rotated natural scene), and more distractors. Following each trial participants were asked to determine the direction to which T_2 was rotated, and the dependent variable was whether the participants answered correctly.

The experimenter then reentered the room and showed the participant three faces, one of each race that was randomly selected from the face stimulus set. Participants were given the forced-choice of “yes” or “no” in answering whether they had seen the faces in the practice trials. The participants’ answers were not recorded or analyzed because this recollection task was only a ploy to reaffirm the cover story that they would have to identify the faces after the actual trials. Participants were reminded to pay particular attention to the one face and one rotated natural scene in each series, and then they were left to complete the 270 actual trials.

Following the RSVP task, participants were given a measure ostensibly assessing interest in video games and a basic demographics measure.

The questionnaire asked how much participants enjoyed playing videogames, how often they played, whether they owned any video game systems, and if so, which ones. Participants then completed a demographics questionnaire assessing their age, gender, and race.

Finally, participants were fully debriefed and thanked for their participation. During the debriefing, participants were probed for suspicion about the actual hypothesis of the study. All participants reported that they did not suspect that this study had anything to do with race before playing the video game. Some claimed that they knew that this was a race study during the video game, when they started to realize that the faces were of three distinct races. These participants were not dropped from analysis, however, because their suspicion cannot have influenced their automatic allocation of attention to these faces. The rate at which the stimuli were presented was too fast for participants to consciously control their attention-allocation processes.

Results

A mixed factorial analysis of variance (ANOVA) was conducted, with lag (1, 2, 4) and T1 type (Black, Indian, White) as within-subject factors, and the race of participants (Black, White) as the between-subject factor. The ANOVA confirmed that our rapid serial visual presentation task induced attentional blink with a main effect of lag, $F(2,48)=12.33$, $p < .001$. Examining the mean accuracies showed that Black and White participants performed better on the T2 task at lags 2 and 4 than at lag 1. The ANOVA also showed a main effect of race, $F(1,49) = 7.40$, $p < .01$, suggesting that Black and White participants differed significantly in their accuracy on the T2 task. In addition, the ANOVA showed a significant interaction between lag and race of participants, $F(2,48) = 4.37$, $p < .05$, suggesting that the amount of attentional blink experienced by Blacks and Whites differed significantly. There was a marginally significant main effect of T1 type, $F(2,$

48) = 2.76, $p = .074$, meaning that T1 type was not a significant factor in the amount of blink participants experienced.

To determine the nature of the interaction between lag and race of participants, follow-up tests were conducted and showed that at lag 1, the mean accuracies were comparable between Black and White participants across the three T1 types. At lags 2 and 4, however, Black participants' mean T2 performance was lower than White participants' across all three T1 types. In other words, Blacks recovered slower than White participants from the attentional blink induced by all three T1 types. These results are consistent with our hypothesis that Black participants find it more difficult than White participants to disengage from faces of all three races.

Discussion

Our data show that faces of the ingroup, traditional outgroup (White) and the non-traditional outgroup (Asian-Indian) held the attention of Black participants significantly more than that of White participants. This longer engagement with the faces (T1) came at the expense of processing T2, so Blacks experienced larger attentional processing impairment for T2, on average, missing which direction the T2 natural scene was rotated more times than Whites. These results are therefore consistent with our working hypothesis that Blacks are more attuned to racial and identity information than Whites are.

These results are consistent with the research on social identity threat (e.g., Major & O'Brien, 2005; Kaiser et al., 2006) and social identity contingencies (Purdie-Vaughns et al., 2008) that informed our hypothesis. Our data suggest that, insofar as faces are valid encoders of racial cues, minority group members are more attentive, even at the automatic level, to the racial and identity information in faces than majority group members.

While the findings of this present research are consistent with existing literature on attentional

asymmetries, this study is novel in three respects: (1) the automaticity of the attentional asymmetry, (2) the inclusion of both majority and minority group members as participants, and (3) the inclusion of Asian-Indians as a non-traditional outgroup cues¹. In capturing the differences in Blacks' and Whites' attentional blink for ingroup and outgroup faces, the RSVP paradigm used in this study can help to generate a new line of research exploring how the daily experiences of minority group and majority group members are affected by automatic attentional biases.

The implications of these novel findings are significant to our understanding of the impact of the minority status on the minority experience. The social identity threat and social identity contingencies literatures have established that members of stigmatized groups have to contend with greater attentional demand. They must pay more attention to their surroundings to survive and succeed. Our current study attempts to extend this attentional asymmetry to an automatic level. Even without explicit threat conditions in this experiment, Black participants exhibited greater attentional allocation to racial and identity information, as represented by faces. This unconscious aspect of attentional asymmetry between Blacks and Whites adds to and complements the research on the conscious aspects such as threat, thus moving us toward an

understanding of the underlying mechanisms that drive the extra-vigilant minority experience.

Limitations and Future Research Issues

The theoretical underpinnings of the current findings are based on the effect of minority status on attention. The inverse of this framing—why Whites perform better on the T2 task than Blacks—was not explored. Could there be psychological reasons or societal influences that cause Whites to dwell less on faces as opposed to Blacks dwelling more on faces? Even if Blacks' dwelling more on faces contributes to this attentional asymmetry, does it have to be attributed to minority status? Based on these data, an argument could be made that Blacks simply experience more attentional blink in general than Whites do—not that they are attending to the racial information in faces. Two controls should be used in future research to clarify our findings. First, non-face T1 stimuli should be used. If Blacks perform at the same level as Whites on an RSVP task with, for example, common household objects as T1 stimuli, this would rule out the interpretation that Blacks experience greater attentional blink than Whites in general. Furthermore, to make sure it is the racial information encoded in faces that drives the attentional blink effect for Blacks, rather than the faces themselves, race-relevant non-face cues should be used. Together, these controls would strengthen our interpretation that Blacks attend to race-relevant cues at the automatic level more than Whites.

Concluding Remarks

We have developed what we believe to be a useful paradigm for studying between-race attention-allocation effects at the automatic level. Our study represents just the first step in what may be a fruitful line of research exploring the unconscious attentional aspects of minority experience, based on our predictions from literature on social identity threat and social identity contingencies. ■

1 Asians have been largely neglected in race research. Yet according to the 2000 census, Asian-Americans are the fastest growing population in America, and Asian-Indians are the third largest Asian group (Barnes & Bennett, 2002). We wanted to expand the idea of the outgroup to Asian-Americans because our society is increasingly diverse, with U.S. Census projections that by 2042 Whites will lose plurality and that Asians will grow from 5% to 9% of the American population (Bernstein, 2008). An increasingly diverse society means that any ingroup will have multiple outgroups, which necessitates the stripping of the traditional Black-White pairing for the traditional ingroup-outgroup dynamic. The present finding suggest that Asian-Indian faces are as much a part of Blacks' attentional bias as Black and White faces are.

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Effects of Cross-Modal Cues on Spatial Attention

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This study assesses the cross-modal influence of auditory cues on the performance of a visual task that requires spatial attention. We build on existing research by teasing apart the effects of alerting versus orienting cues in a 2 (task condition: cue vs. no cue) \times 2 (cue type: alerting cue vs. orienting cue) \times 2 (target location: center vs. periphery of hemifield) design. The dependent measure is reaction time. For the task, a variety of novel shapes were presented on each side of the screen. Participants responded with specific keys depending on the location of the shape. By random assignment, some of the trials were preceded by a tone, while others did not have any cue associated with them. Results showed that cues improved performance, with orienting tones having a greater impact than alerting signals.

Introduction

Visual attention facilitates the processing of information on countless tasks crucial to human functioning. Learning about the factors which guide attention, then, is of great importance in understanding this critical function, and may even aid in the creation of programs to help people who have disorders affecting it, such as attention deficit hyperactivity disorder (ADHD) or Alzheimer's disease. This study aims to enhance our understanding of the visual attention system and the factors that facilitate its performance by showing that the ability to respond to a visual task will be augmented when attention is cued by an auditory tone. Furthermore, we predict that the type of cue (alerting vs. orienting) and target location (center vs. periphery of left or right hemifield) will impact the degree of facilitation. Specifically, we predict that orienting cues, which direct attention to a specific hemifield, will decrease reaction time more than alerting cues, which act as reminders to keep the focus of attention sustained on the task. In addition, we predict that the stimuli located in the center of the focus of attention will be responded to faster than those located in the periphery. Therefore, this is a 2 (task condition: cue vs. no cue) \times 2 (cue type: alerting cue vs. orienting cue) \times 2 (target location: center vs. periphery of hemifield) design, where the dependent measure is reaction time.

Attention: Alerting vs. Orienting Systems

Although there is probably no single definition that encompasses the multitude of processes referred to as "attention," it can be described as the cognitive function which controls the mechanisms for the storing and retrieval of memories and for the perception and selection of information among competing stimuli in our environment (Kenemans, 2000). Functional neuroimaging has enabled the study of brain areas associated with attention, and research has uncovered the presence of three networks involved in its function: alerting, orienting, and executive, each of which activates a different part of the brain and plays a unique role (Posner & Rothbart, 2007). Alerting and orienting are of prime interest in this study and therefore will be the only components described in further detail.

The alerting network is involved in the activation and maintenance of high sensitivity to incoming stimuli. Experiments that use warning signals prior to the presentation of stimuli activate this type of network (Posner & Peterson, 1990). In contrast, the orienting network is concerned with the selection of information from the sensory signals our brain receives. The orienting mechanism can be broken down into two parts: overt, as when eye movements accompany the shifting of visual attention; and covert, when the change in visual

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attention is not associated with any eye movements (Schmitt, Postma, & De Haan, 2000). However, both overt and covert shifts of attention activate the same brain regions (De Haan, Morgan, & Rorden, 2008). For this reason, the present study will not control for participants' eye movements, or saccades. This has the additional benefit of making the study more realistic, since in everyday life people are constantly looking around their environment.

Fernandez-Duque and Posner (1997) found that the alerting network is completely independent from the orienting network. The alerting mechanism is uniform across the visual field and does not discriminate between auditory and visual warning signals. On the other hand, the orienting network has spatial precision over a localized visual area but it also responds to both visual and auditory stimuli similarly. Fernandez-Duque and Posner found that reaction time during a unimodal experiment decreased when participants used the alerting system. The response time also decreased if the orienting mechanism was accessed. However, each type of mechanism had an independent contribution to the improvement in task performance, suggesting that signals that activate these networks are processed through separate neural pathways. This will become important later in the discussion of how signals activate these networks. What the study by Fernandez-Duque and Posner did not explore, and what this study tries to answer, is whether the orienting and alerting networks accessed by cross-modal cueing facilitate response time equivalently or not.

Types of Cues And Factors That Influence Them

The alerting cue is defined as a spatially uninformative or non-predictive cue (Driver & Spence, 1998). Thus, a tone that comes on from time to time to alert participants but does not direct attention to a specific location in space is an alerting cue. For instance, when a fire alarm starts beeping, it suggests there is a potential danger, which captures attention; however, it does not give any information

about the position of the fire. Alternatively, a perceived signal that directs attention to a specific part of the environment, described as a predictive cue, triggers the use of the orienting network (Driver & Spence, 1998). An example of a predictive cue, also defined as an orienting cue, is when a car from the right side honks at the car in front. This sound does not only capture attention, but also directs it to the location of the car. However, orienting cues are not simply alerting sounds with more information; rather they are processed through a separate neural network, as suggested previously by Fernandez-Duque and Posner (1997).

For each of these types of cues, there can either be a reflexive reaction or a voluntary, conscious reaction. These types of cognitive mechanisms for shifting attention are described as exogenous and endogenous, respectively (Schmitt et al., 2000). Research has demonstrated that the effects of exogenous (reflexive) cues on attention are smaller and shorter-lived than those of the endogenous (voluntary) cues (Driver & Spence, 1998). Furthermore, exogenously cued attention is quick and automatic, and voluntary endogenous attention processes cannot override it in most situations (Schmitt et al., 2000). Also, exogenous cues depend on "stimulus saliency" a mechanism by which a stimulus that stands out with respect to its environment is favored, while endogenous mechanisms are used according to a person's strategic needs (Zhou, 2008). In the present study, participants encountered either exogenous cues designed only to keep participants alert, or endogenous cues, which allowed them to choose appropriately where to orient their attention. Of course, the orienting cue is partly exogenous because it does stimulate attention involuntarily, but if participants are explicitly told to use the information the cue provides to voluntarily direct their attention to a specific place in the environment, the cue can be considered mainly endogenous. This was the case in the present experiment.

In addition to the type of cue presented, the effectiveness of a cue in enhancing performance

is dependent on the length of time it is presented. As presentation time increases from 0 to 100 ms, a cue tends to yield a more successful response; but performance peaks at this value and tends to decrease the longer the cue is presented (Wright & Ward, 1994). If the signal remains for a relatively long period of time (approximately 300 ms), performance may even decrease to below the no-cue baseline, due to a phenomenon called Inhibition of Return (IOR) (Zhou, 2008). IOR refers to the suppression of the processing of stimuli that had recently been the focus of attention (Posner & Cohen, 1984). To maximize participants' ability to perform well on the experimental tasks, the signal in this study was presented for 100 ms, consistent with values established in the literature.

The time interval between presentation of cue and appearance of stimulus is also important. Spence and Driver (1997) found that the fastest reaction time occurred when the delay between the presentation of the cue and the stimulus was 200 ms. Accordingly, we used a cue-to-stimulus delay of 200 ms in the present study as well.

Cross-Modal Interactions

Most of the experiments that assess the impact of cues on performance of a task are unimodal, relying on a single sensory modality—for example, a visual cue given during performance of a visual task (Fernandez-Duque & Posner, 1997; Driver & Spence, 1998; Santangelo, Ho, & Spence, 2008). This research has shown that a same-sense signal facilitates performance (Carrasco, Talgar, & Cameron, 2001). But the everyday environment provides not just one, but a multitude of sensory stimuli to which attention needs to be directed. Therefore it is necessary to study the interaction between different sensory modalities to gain a better picture of attention processes in real world situations.

Researchers have begun to investigate such cross-modal scenarios. The nascent literature on the subject does suggest that a cue from one sensory modality can enhance the detection of a stimulus in a different sensory modality (Driver & Spence, 1998;

Santangelo, Ho, & Spence, 2008). For example, experiments examining the influence of auditory cues on visual tasks have shown faster reaction times on visual target detection and elevation discrimination (Turatto et al., 2005; Driver & Spence, 1997; McDonald, Wolfgang, Di Russo, & Hillyard, 2003).

In addition, Frassinetti, Pavani, and Ladavas (2002) found that improved response to a combination of stimuli was due to more than the sum of the individual stimuli; instead the response enhancement was super-additive – that is, even if a visual and an auditory stimulus did not evoke a response separately, when added together, their combination produced a surprisingly strong response. Indeed, it appears that the auditory and visual modalities are mapped together in the brain in such a way that if an auditory cue is presented from a certain direction, the visual modality re-maps to accommodate for this change, shifting the eye to the direction of the tone (Driver & Spence, 1998).

The present study expands on existing literature by modifying the types of auditory cues presented in an attempt to answer specifically what types of auditory tones provide the greatest improvement on a visual task.

Spatial Attention and Target Location

One theory about spatial attention suggests that an object's location in the field of focus plays an important role in how it is attended to. In one study by Cave and Bichot (1999), a stimulus was either presented in the center of a box that was placed in the middle of the screen, or outside of the corners of the box. The results showed that the stimulus presented at the edges of the box resulted in slower response times, indicating that less attention was directed to peripheral areas when compared to the center. An additional study found that the farther an object was from the center of the screen, the more time participants needed to respond to it. It was concluded that attention works as a gradient: the center is clearest, and attention dissipates with increasing distance from the center (Greenwood & Parasuraman, 2004; Chen & Treisman, 2008).

The “spotlight” analogy is used as a metaphor to visualize these characteristics. Just as a beam of light shines on an object in a dark room, attention focuses on a particular target in the environment (Posner, 1980). The focus of attention is very narrow at the center and therefore encompasses very few objects. This increases the cognitive resources that provide clarity about the target at a specific location: thus, the objects in the center of the beam of attention are seen fastest and with the most details. At the same time, attention becomes broader farther away from the center, thus inclusive of more objects. This means that more objects can be visualized in the periphery of the spotlight, but cannot be seen as clearly or as quickly (Cave & Bichot, 1999).

This beam of attention can be dynamically constricted or expanded according to task demands. A constricted spotlight of attention is used when arrays are large and discrimination is difficult due to similarity between the target and the distracters or other items in the environment. Expansion is optimal when targets are easily detected because they “pop out” from the rest of the items in the visual field (Greenwood & Parasuraman, 2004).

Although the metaphor of the spotlight has been criticized because of its over-simplicity in describing the intricate mechanism of attention, the characteristics mentioned above are indeed components of the system (Cave & Bichot, 1999). However, research has not yet explored whether this gradient of attention is present with overt shifts of focus or exclusively under covert conditions. As mentioned previously, overt shifts occur when eye movements accompany the shifting of visual attention while covert shifts occur when the change in visual attention is not associated with any eye movements (Schmitt, Postma, & De Haan, 2000). In the present experiment, participants are told to fix their gaze in the center of the screen at the beginning of every trial, but they are free to move their eyes anywhere on the screen when searching for the location of the figure; thus it will examine overt shifts in attention.

Hypotheses

The current study has three main hypotheses:

1. An auditory cue will facilitate response time on a visual task.
2. An orienting cue, which predicts the location of the stimulus, will improve performance (as compared to the absence of the cue) more than an alerting cue, which keeps the participant vigilant.
3. When shifting attention, the window of focus will move to the location attended.

Although, at the periphery of the visual field, the stimulus found in the relative center of the focus of attention will be detected faster than the one in the extreme margin.

Method

Participants

This study was completed by 20 young adults between the ages of 18 and 23. They were recruited through the York University Undergraduate Research Participant Pool (URPP) and received course credit. Participants were provided with an outline of the study prior to the testing and were debriefed at the end of the experiment. They could choose to stop the testing at any time.

All subjects were screened and found to have normal or corrected-to-normal vision in addition to having normal hearing. A series of neuropsychological tests confirmed that all participants were without cognitive impairments that could affect performance on the attention tasks.

Exclusion criteria included speaking English for fewer than 5 years, a previous history of stroke, brain tumor, brain injury, depression, and taking medication that could affect cognitive functioning, such as Ritalin (Methylphenidate). All participants were found to be functioning normally, and thus none were excluded from the experiment.

Apparatus and Stimuli

The experiment was programmed in SuperLab Pro Edition Version 4.5 and was presented on a

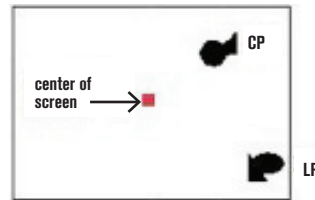
Figure 1

Example of a novel shape used as a stimulus



Figure 2

Location of stimuli (CP and LP) in relation to the center of the screen



1

2

Macintosh computer. The visual part of the experiment was shown on a monitor with a resolution of 1680 pixels wide \times 1050 pixels long, while the actual screen size was 43.5 cm wide \times 27.35 cm long. Participants heard the auditory cues through a set of two speakers located on either side of the screen, 35 degrees from fixation. The 100 ms duration tone was created using the program Audicity Version 1.2.5 to have 1500 Hz and was presented at 82 dB as measured from the participant's ear.

The stimuli were unfamiliar objects created by superimposing different shapes upon each other using Microsoft PowerPoint Version 12.0 to cover a surface area of 6.25 cm² (2.5 cm wide \times 2.5 cm long). Their color was black and they were presented on a white background.

Procedure

Participants were tested in a well-lit laboratory room at York University. They were seated on a chair in front of the computer monitor. Before beginning the experiment, they completed a demographics questionnaire assessing their age, gender, preferred handedness, spoken languages, years of education, general health, and any medications they may be taking. Then, during the actual experiment, they were instructed to hold their hands on the keyboard, with the fingers of their dominant

hand on the "i" and "m" keys, while the thumb of the non-dominant hand was placed on the spacebar. Participants only used the spacebar when navigating through the instructions.

The experiment consisted of two tasks: one that tested the effects of an orienting cue and another that tested the effects of an alerting cue. As part of the task, 20 novel shapes were presented in a random order on the screen; they appeared one at a time (Figure 1). There were two blocks of each type of task with 80 trials per block for a total of 320 trials. These blocks were administered as four randomly assigned blocks to avoid order effects. Before the presentation of the actual experiment, participants practiced one block composed of five trials for each type of cue. This procedure was employed to make sure they understood the instructions and were comfortable with the task.

In the orienting task, 50% of the 160 trials, thus 80 trials, were preceded by a valid auditory cue (that is, an auditory cue that directed attention to the correct hemifield), while the other half did not have any cues associated with them. The trials were randomized between the cue and no-cue situations. On the other hand, in the alerting task only 25% of the 160 trials, thus 40 trials, were accompanied by the tone. Since an alerting cue is uninformative, it is important that it not be presented

too many times lest participants become accustomed to and start ignoring it (Robertson, Mattingley, Roden, & Driver, 1998; Van Vleet, & Robertson, 2006). Thus, the number of cued trials was decreased for the alerting task to prevent habituation. The cue in alerting trials was presented to both sides simultaneously and thus did not predict which visual hemifield the stimulus appeared in; rather its purpose was to alert the participant to stay focused on the task in a sustained manner. Participants were explicitly told that they should use the sounds as a reminder to be attentive on the task.

In addition to manipulating the auditory tone, the experiment tested the effects of stimulus position. There were no stimuli presented in the center of the screen; all the stimuli were found in two different locations in the periphery. Lateral periphery (LP) stimuli were placed at a visual angle of 31.5 degrees from the center, or at the extreme margin of the attentional window. Central periphery (CP) stimuli were placed at a visual angle of 19.3 degrees from the center, or in the center of the attentional window (Figure 2).

Each trial began with the appearance of a fixation cross (black cross on a white background) at the center of the screen, where the participants were instructed to look. It was displayed for 500 ms, followed by either a cue of 100 ms or in the case of the no-cue trials, a blank screen for 100 ms (Figures 3 and 4). In order for the participants to have enough time to process information about the cue, a 200 ms delay appeared, consisting of a blank screen. To make the conditions equivalent, the no-cue condition also contained 300 ms total delay, consisting of blank screens (see Figure 4). A stimulus then appeared and remained on the screen until the participant responded. While there was only one correct key for each trial (depending on the case, it was “i” or “m”), if the participants pressed any key, the trial would continue to the next one. For each trial, the answer was recorded and scored to check if it was the correct choice.

While the task involved deciding between upper and lower figures, the cues were presented

either to the left, right, or both sides. This orthogonal design was chosen so that the processing of the task information (up vs. down) would be different from the processing of location of the cues (left vs. right). Thus participants were required to pay attention to the task and not just respond automatically to the cues.

Results

Experimental tasks

This experiment was a 2 (task condition: cued vs. no cued) \times 2 (cue type: orienting vs. alerting) \times 2 (target location: center vs. periphery of hemifield) within-subjects design. The dependent measure was reaction time (RT). Incorrect answers were excluded from analyses. The data from median RTs were then analyzed using a repeated measures Analysis of Variance (ANOVA).

Main effects were found to be significant for all three independent variables: task condition [$F(1, 19) = 21.11, p < .001, \text{partial } \eta^2 = 0.53$], cue type [$F(1, 19) = 7.76, p < .012, \text{partial } \eta^2 = 0.29$], and location [$F(1, 19) = 26.47, p < .001, \text{partial } \eta^2 = 0.58$] and an interaction was present between task condition and cue type [$F(1, 19) = 5.66, p < .028, \text{partial } \eta^2 = 0.23$]. No other significant interactions were found.

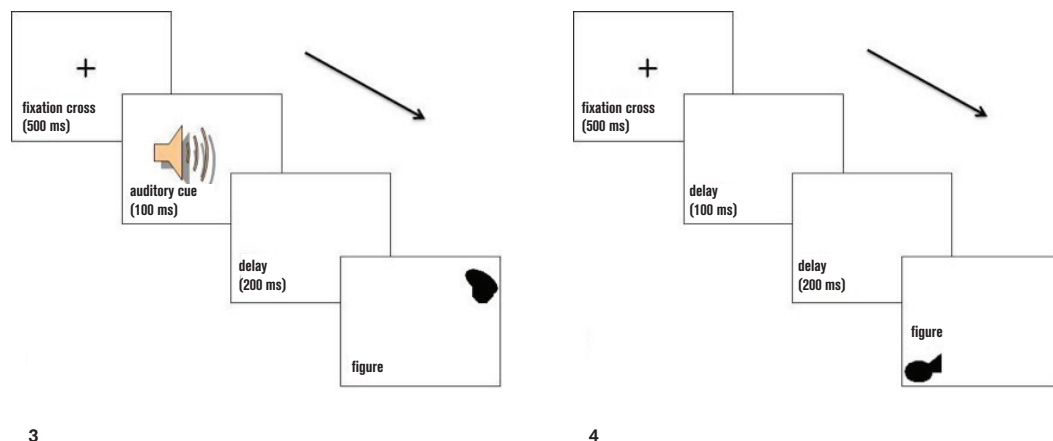
As predicted, RTs were significantly faster on the cued trials ($M = 419 \text{ ms}, SE = 18.99$) than on the non-cued trials ($M = 444 \text{ ms}, SE = 21.58$), replicating previous research (Driver & Spence, 1998; Turatto et al., 2005; Santangelo, Ho, & Spence, 2008). There was also a significant main effect for the different cue types (orienting, alerting). The overall performance on the orienting cue type ($M = 440 \text{ ms}, SE = 21.61$) was slower than on the alerting cue type ($M = 422 \text{ ms}, SE = 19.14$). However, this main effect was qualified by a significant task (cue, no cue) by cue type (alerting, orienting) interaction. Follow-up simple effects analyses showed that orienting cues facilitated response times to a greater extent (mean difference = 35 ms, $p < .05$) than alerting cues (mean difference = 15 ms, $p = .052$). Performance on the

Figure 3

Example of a trial used in the cued procedure

Figure 4

Example of a trial used in the non-cued procedure



cued orienting trials ($M = 423$ ms, $SE = 21.11$) was significantly faster than on the non-cued orienting trials ($M = 458$ ms, $SE = 22.56$), and performance on alerting trials ($M = 415$ ms, $SE = 17.41$) was marginally faster than the non-cued alerting trials ($M = 430$, $SE = 21.32$) (Figure 5, next page).

Response time also varied depending on location. As predicted, responses were significantly faster for items presented in the center of the hemifield ($M = 425$ ms, $SE = 20.18$) than for items presented in the periphery of the hemifield ($M = 438$ ms, $SE = 20.19$).

Discussion

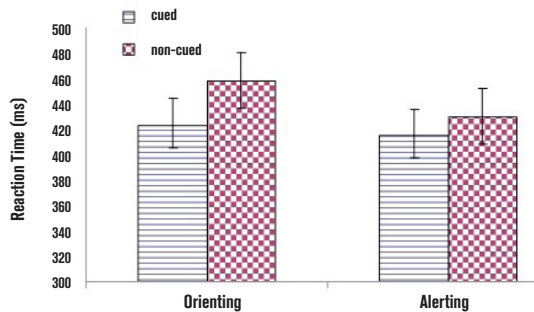
This study examined whether auditory cues facilitate performance on a visual task, whether orienting cues facilitate performance to a greater extent than alerting cues, and whether target location influences performance. The results support the three hypotheses. Overall, this study found that an auditory cue significantly improved performance on the task, with orienting cues facilitating response times to a greater extent than alerting cues. In addition, participants responded more quickly to targets in the center than to those in the periphery.

An interesting and unpredicted outcome was also found: Although the alerting and the orienting tasks required the participants to engage in the same response when the stimulus appeared on the screen, participants performed on average slower on the orienting task. This main effect of cue type was further clarified by the interaction with task condition. When comparing cued orienting and alerting trials, reaction time was similar for both. However, for the non-cued trials, participants performed significantly worse on the orienting task than on the alerting task.

There are several possible explanations for this unexpected finding. First, it is possible that participants became reliant on the orienting cue to locate the figures. They may have depended on the external information to guide their attention, so that when this cue was absent they had to internally direct their attention (Ladavas, Carletti, & Gori, 1994). This attention shift possibly resulted in their slower response on the non-cued trials. In contrast, participants did not rely on the alerting cue to guide their attention to a spatial location. Since this type of tone did not predict where the figure would be, they had to internally guide their attention at all times (Hsieh & Allport, 1994). Therefore, the alerting cue

Figure 5

Interaction between task condition and cue type



type may have sustained attention without encouraging dependency on the cue. An analogy would be using a GPS navigation system to navigate to an unknown location. When people receive guidance from a navigation system, as in the orienting cue situation, then they find the location more quickly. However, if the navigation system stopped working they would have more difficulty finding the location than if they had never had the navigation system in the first place, because they were relying on it.

Participants might also have been less accustomed to relying on alerting cues because they were presented less frequently than the orienting cues. The orienting cue appeared 50% of the time, while the alerting cue was present in only 25% of the trials. These values were chosen in accordance with common practice as described in the literature (Robertson et al., 1998; Van Vleet & Robertson, 2006). However, since no other study has compared the two, it is possible that the number of times the cue was presented impacted how accustomed participants became to the sounds. Since the orienting cue appeared more often, participants may have begun to rely on it more than in the alerting case. Hence, when the cue was absent in the orienting trials, they did poorer than if they had never had a cue in the first place.

Another explanation might be related to how these two types of cues are processed by the brain. An alerting signal is an exogenous, reflexive cue that is processed quickly and automatically (Driver & Spence, 1998; Schmitt et al., 2000). Thus, it can be inferred that participants would react quickly on these types of trials. On the other hand, an orienting cue is endogenous or voluntary and requires participants to use it according to their strategic needs (Schmitt et al., 2000; Zhou, 2008). While it did provide some stimulating effect, participants needed time to decide how to react to this type of cue, which could help to explain the slower response times in the orienting trials.

Lastly, the amount of time for which the cue was presented might have had an impact on the results. On average, for a cue to be effective, it needs to be present for 100 ms (Madden, 1990). However, the actual effectiveness of the presentation time for the orienting and alerting cues are slightly different. Cue effectiveness in alerting trials increases rapidly from 0 to 100 ms, peaks around 100 ms and usually decreases with further increase in time. On the other hand, the optimal range for the orienting cue is much larger and it increases more gradually from 0 to 300 ms (Wright & Ward, 1994). This experiment presented both cues for 100 ms in order to make the two blocks equal. However, the intrinsic difference in the way these sounds are perceived might have led to the slower processing of the orienting cue as opposed to the alerting cue. Future studies might investigate this phenomenon to see what impact it has on performance.

Our third initial hypothesis predicted that the location of the stimulus would affect performance on the visual task. Specifically, we predicted that the stimulus found in the relative center of focus would be detected faster than the one in the extreme margin. Results showed that central targets were responded to significantly faster than peripheral cues, even when shifting attention from one location to another. These findings add to the current literature (Greenwood & Parasuraman, 2004). It is known, through the “eccentricity effect,” that a

stimulus in the center is processed more efficiently than the same stimulus in the periphery (Chen & Treisman, 2008). However, the present study showed that the same process occurs even with the shifting of attentional focus. Since not enough research has been conducted on the topic of attentional shifts, further studies are needed to fully understand the processes at hand. One important question that should be assessed concerns the mechanisms in the brain that control for this gradient of attention from center to periphery. In addition, it would be instructive to conduct research that manipulates the target location on a wider spectrum. This could provide more detailed information about how figures are attended to when they change their place in the environment.

Overall, the current experiment showed that auditory cues improve performance particularly if they provide information regarding the location of the target in the environment. This effect is more prominent in the center of the focus of attention than in the periphery.

The implications of this line of research are extremely important, providing a framework for the creation of cognitive rehabilitation programs for patients with problems sustaining attention. Examples include those suffering from Alzheimer's disease or unilateral neglect, a condition in which patients fail to report, respond, and orient to novel

or meaningful stimuli presented to the side of the body contralateral to a brain injury, usually stroke (Arene & Hillis, 2007; Robertson, Mattingley, Roden, & Driver, 1998; Frassinetti, Pavani, & Ladavas, 2002; Van Vleet & Robertson, 2006).

Several different treatments have been proposed for unilateral neglect, one of which includes using auditory cues to enhance attention to the contralateral side of the body. This type of research has been attempted in a laboratory setting and has shown improvement in patients' ability to detect objects as long as auditory cues were present (Arene & Hillis, 2007). This finding could be applied outside the lab, with the use of a small auditory device similar to a hearing aid connected via Bluetooth technology to a tone-emitter. With such a set up, unilateral neglect patients would benefit from increased attention to the side of the world they generally ignore, leading to an increase in quality of life. While it may be premature, another possible venue for this research includes helping the elderly population to increase their ability to pay attention (Craig & Byrd, 1982; Mital, 1994; Ostir, Carlson, Black, Rudkin, Goodwin, & Markides, 1999) through similar devices. The more we fine-tune our understanding of the processes at work in cross-modal cueing, through studies such as the present one, the better the cognitive therapies we will be able to create. ■

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Objectified Body Consciousness, Depression, and Eating Disorders: The Importance of Control Beliefs

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Objectification theory posits that our society's focus on the female body negatively impacts women. Women and girls who internalize the idea that appearance should be valued above all other traits and who constantly monitor their bodies to measure them against society's ideal are said to have Objectified Body Consciousness (OBC). One aspect of OBC is appearance-control beliefs, that is, women's beliefs about their ability to control their appearance, body shape, and weight. Individuals can have an internal or external locus of control in this domain. The present study evaluated the relationships between OBC, appearance-control beliefs, depression, and eating disorders in adolescent girls, a relatively under-studied population with respect to these concepts (Morandi & Huang, 2008). Results showed that OBC predicted eating disorder symptoms but not depressive symptoms, revealing a limit to these disorders' comorbidity, and indicating that objectification theory is a useful framework for the study of eating disorders in adolescent girls. External locus of control and belief that appearance cannot be changed were associated with depressive symptoms but not with anorexic-type eating disorder symptoms. Eating to cope with emotions was associated with eating disorder symptoms, depressive symptoms, and an external locus of control, suggesting that emotional eating is a risk factor for both eating disorders and depression. Together, these findings provide support for the predictions of objectification theory and highlight the special importance of control beliefs in eating and mood disorders.

Introduction

More than a decade ago, Fredrickson and Roberts (1997) developed objectification theory as a means of understanding how our culture's sexualized focus on the female body could contribute to the mental health problems that affect women disproportionately, particularly eating disorders and depression. Objectification theory posits that our culture's focus on the female body causes girls and women "to internalize an observer's perspective as a primary view of their physical selves" (Frederickson & Roberts, 1997, p. 173). This internalization leads to what McKinley and Hyde (1996) call Objectified Body Consciousness (OBC), composed of three parts: body surveillance, body shame, and appearance-control beliefs. Body surveillance is the habit of taking an onlooker's perspective of the body; body shame arises from being embarrassed by the body because it does not measure up to internalized cultural standards of beauty, which are often unattainable (Wolf, 1991); and appearance-control beliefs involve accepting the false notion that anyone can reach the cultural ideal with enough effort (McKinley & Hyde, 1996).

A number of negative consequences have been associated with the first two of these components, body surveillance and body shame. They have been linked to decreased performance on cognitive tasks, lowered self esteem, and lack of awareness of bodily states (e.g., Frederickson, Roberts, Noll, Quinn, & Twenge, 1998). There are also strong connections between body surveillance, body shame, eating disorder symptoms, and depressive symptoms (e.g., Hyde, Mezulis, & Abramson, 2008). However,

while depression and eating disorders are often comorbid, they are distinct mental health problems. Whether a woman dissatisfied with her body will experience depressive symptoms, eating disorder symptoms, both types of symptoms, or no such symptoms is not explained by body surveillance and body shame alone. One goal of the present study, therefore, was to determine if appearance-control beliefs, the third component of OBC, had special importance in the development of depression and/or eating disorders in women with OBC. Understanding the impact of control beliefs would allow clinicians to develop successful treatment strategies for women with depression and eating disorders and could be helpful in prevention work with at-risk populations.

The relationships suggested by prior research between an external versus internal locus of control (the latter including appearance-control beliefs) and eating and mood disorders are unclear. While much research has indicated that an external locus of control is associated with depressive symptoms (e.g., Miller, 1988; Nowicki, & Strickland, 1971), results of studies assessing the impact of control beliefs (i.e., internal loci) have been mixed. On the one hand, qualitative studies as well as clinicians' anecdotes and opinions have supported the idea that eating disorders stem from a lack of personal control (Watt, Sharp, & Atkins, 2002). However, there has not been much empirical evidence to bolster this assertion. Indeed, several studies (e.g., Watt et al., 2002; Furnham & Atkins, 1997) suggest that individuals whose eating pathology includes restricting and other symptoms

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Table 1

Proposed Relationships between Control, Eating Disorders and Depressive Symptoms

Locus of Control	Proposed Relationship	Symptom Type
External Locus of Control (appearance beliefs)	predicts	Depressive Symptoms, Symptoms of Bulimia, Binge Eating
	does not predict	Symptoms of Anorexia
Internal Locus of Control (appearance beliefs)	predicts	Symptoms of Anorexia
	does not predict	Depressive Symptoms, Symptoms of Bulimia, Binge Eating

of anorexia may have an internal locus of control, while individuals with bingeing and other bulimic symptoms do not.

Control beliefs are just one aspect of OBC. For women who are experiencing the other OBC-cognitions of body surveillance and body shame, restricted eating and similar symptoms can be seen as an attempt to force the body to adhere to the thin ideal. However, bingeing, purging, and other symptoms of bulimia do not usually result in weight loss (Mitchell, Pomeroy, & Huber, 1988). If these behaviors do not help women who are ashamed of their bodies achieve body states closer to the thin ideal, what purpose could they serve? Heatherton and Baumeister’s (1991) escape theory of binge eating provides one possible explanation. They posit that binge eating is motivated by a desire to escape negative feelings about the self. Indeed, binge eaters report a reduction in negative affect after bingeing (Davis & Jamieson, 2005). Corstorphine, Mountford, Tomlinson, Waller, and Meyer (2007) found that binge eaters lack healthy techniques to deal with negative emotions while non-bingers report feeling more in control of their negative emotions because of adaptive emotion regulation techniques. In sum, research has shown that binge eating and other bulimic symptoms can be viewed as maladaptive coping strategies for feelings of lack of control

and thus can serve a purpose for women experiencing OBC.

The present study aims to assess whether the Objectified Body Consciousness model predicts depressive and eating disorder symptoms in young adolescent girls, taking into account the previously under-studied impact of appearance-control beliefs in the development of these disorders. In addition, the use of adolescent samples must be emphasized, as the majority of OBC studies have examined this construct in college students and older women only. This is an unfortunate oversight: adolescence is a time when many girls first become dissatisfied with their bodies and feel pressure to conform to societal standards of beauty (McKinley & Hyde, 1996). Adolescence is also a time of heightened risk for eating disorders and depression (Hyde, Mezulius, & Abramson, 2008), two disorders centrally implicated in the OBC model. Our focus on appearance-control beliefs is also significant. They are an understudied aspect of objectification theory, even though research from other theoretical orientations has suggested that loci of control may contribute to the development path of depression and eating disorders (see Figure 1). We aim to clarify this development path with the current research.

Our model yields the following predictions. First, based on the findings that OBC is connected to depression and eating disorders in

women, we predicted that higher levels of objectified body consciousness will be associated with higher levels of depressive symptoms and eating pathology in a diverse sample of young adolescent girls. Second, using the research on control and eating disorders, we predicted that an internal locus of control (for appearance-beliefs as well as more general domains) will be associated with higher levels of eating disorder symptoms. Third, based on research that indicates external locus of control is related to depressed mood, we predicted that an external locus of control (again, for both appearance and more general domains) would be associated with both depressive symptoms and one specific type of eating pathology, eating to cope with negative affect.

Methods

Participants

Participants were 12- and 13-year-old ($M = 12.3$) girls at a local middle school. Seventy-nine sets of parents (11% of the school's total parent population) agreed to have their children participate. Only girls' responses were used in these analyses. Twenty-nine girls (74% of consenting girls) completed the study. The sample was 10% Asian, 3% African American, 7% Hispanic, 70% Caucasian, and 3% Biracial. Seven percent of participants specified their ethnicity as "other."

Measures

Objectified Body Consciousness

The Objectified Body Consciousness Scale (OBC; McKinley and Hyde, 1996) assesses the extent to which females have internalized cultural standards for the feminine body, feel shame over their bodies, and believe they can make their bodies achieve the cultural standard through hard work. It consists of three subscales with eight items each: Body Surveillance, Body Shame, and Control Beliefs. It uses a 6-point scale that ranges from strongly agree to strongly disagree. Scores range from 24 to 144. Lower scores indicate higher levels of Objectified

Body Consciousness. A low scorer on the Body Surveillance subscale would take an observer's perspective of her body and be more concerned with how her body looks than how it feels (e.g., "I often worry about whether the clothes I'm wearing make me look good"). A low scorer on the Body Shame subscale would feel like a bad person if she could not fulfill cultural expectations for the female body (e.g., "When I can't control my weight, I feel like something must be wrong with me"). A low scorer on the Control Beliefs subscale would believe that she can control her appearance and weight if she tries hard enough (e.g., "I think a person can look pretty much how they want to if they are willing to work at it"). A high scorer on this scale would believe that appearance and weight are controlled by genetics. The body surveillance and body shame subscales have been shown to be valid measures of body esteem (Morandi & Huang, 2008). The appearance control belief scale has been shown to be a valid measure of willingness to engage in restricted eating (McKinley & Hyde, 1996). Cronbach's alpha for this sample was .78 for the Body Surveillance subscale, .63 for the Body Shame subscale, and .67 for the Appearance Control Subscale.

Locus of Control

The Locus of Control Scale for Children (ChLOC; Nowicki & Strickland, 1973) is a self-report measure that examines locus of control beliefs in children through 40 items with yes or no answers. The measure has been shown to have adequate validity and test-retest reliability (Kliewer & Sandler, 1992). The scale measures locus of control beliefs for reinforcement in areas such as achievement, affiliation, and dependency (e.g., "Do you believe that wishing can make good things happen?"). Scores range from 0 to 40. High scores indicate an external locus of control (i.e., the belief that one does not have control over the areas of reinforcement assessed). Low scores indicate an internal locus of control (i.e., the belief that one does have control over the areas of reinforcement assessed). Cronbach's alpha for this sample was .59.

Depressive Symptoms

The Children's Depression Inventory (CDI; Kovacs, 1992) is a 27-item, self-report measure that is a modified version of the Beck Depression Inventory. It is the most widely used instrument for assessing the behavioral and cognitive symptoms of depression in children. It has been established as internally consistent and valid for both clinical and community samples (Smucker, Craighead, Craighead, & Green, 1986; Kovacs, 1992). Children are instructed to choose one sentence from a group of three that best describes the way they have been feeling during the past two weeks (e.g., "I am sad once in a while", "I am sad many times", or "I am sad all the time"). Scores range from 0 to 54. Higher scores indicate higher symptom levels. Cronbach's alpha coefficient for this sample was .89.

Eating Disorder Symptoms

The Children's Eating Attitude Test (ChEAT; Maloney et al., 1988) is a 26-item, self-report measure that assesses children's dieting behaviors and attitudes about eating. The instrument has been shown to have good internal consistency and concurrent validity for child and adolescent samples (Smolak & Levine, 1994). Participants use a 6-point response format (always, very often, often, sometimes, rarely, never) in answering the frequency with which they demonstrate the given attitude or behavior (e.g., "I stay away from eating when I am hungry"). Scores range from 0 to 78. Higher scores indicate higher levels of eating disorder symptoms. Cronbach's alpha for the sample was .88.

Eating as a Coping Mechanism

The Expectancies and Motives for Eating Scale (Stice et al., 2002) is a 10-item self-report subscale taken from the 34-item Expectancies and Motives for Eating Scale created by Hohlstein, Smith, and Atlas (1998). The ten items used assess eating to decrease negative affect and eating as a reward. Participants use a 5-point response format (never, seldom, sometimes, often, always) in answering the frequency with which they eat for each reason (e.g.,

"to forget your worries"). Scores range from 10 to 50. Higher scores indicate higher levels of using eating as a coping mechanism for negative affect or as a reward. Cronbach's alpha for this sample was .93.

Procedure

We first received IRB and school board approval for the study. Letters explaining the study as an examination of adolescent health behaviors were sent to all parents of students in grades six through eight at the school. After permission slips were received, participants were either sent a packet of questionnaires containing the aforementioned measures in the mail or emailed a link to a secure website where they could answer the questions online. Participants were encouraged to complete the questionnaires without the help of their parents. Once the completed packets were received in the mail or recorded on the website, participants were debriefed and compensated with a \$10 gift certificate.

Results

The means and standard deviations for participants' total scores on the Objectified Body Consciousness Scale, the Children's Depression Inventory, the Children's Eating Attitude Test, the Expectancies and Motives for Eating Scale, the Locus of Control Scale for Children, and the Appearance Control Belief subscale of the OBC are shown in Table 1. Table 2 shows the correlations between the Objectified Body Consciousness Scale, the Children's Eating Attitude Test, the Children's Depression Inventory, and the Expectancies and Motives for Eating Scale. Table 3 shows the correlations between the Locus of Control Scale for Children, the Appearance Control Beliefs Subscale of the OBC scale, the Children's Eating Attitude Test, the Children's Depression Inventory, and the Expectancies and Motives for Eating Scale. To examine the research question of whether control beliefs could explain the variation between levels of depressive symptoms and eating disorder

Table 1

Descriptive Statistics for
OBC, CDI, ChEAT, EE,
ChLOC, and OBC
Appearance-Control
Subscale

	M	SD
OBC	80.4	11.40
CDI	9.79	7.34
ChEAT	6.82	7.48
EE	16.6	6.82
ChLOC	14.8	4.33
AC	20.1	5.45

1

CDI = Children's Depression Inventory
ChEAT = Children's Eating Attitude Test
EE = Expectancies and Motives for Eating Scale
ChLOC = Locus of Control Scale for Children
AC = Appearance Control Subscale of the OBC scale
Correlations marked with an asterisk (*) were significant
at $p < .05$ and correlations marked with two asterisks (**) were significant at $p < .01$.

Table 2

Correlations between
Objectified Body
Consciousness, Eating
Disorder Symptoms, and
Depressive Symptoms

OBC	ChEAT	CDI	EE
OBC	-.405*	-.108*	-.085
ChEAT		.450*	.498**
CDI			.530**

2

Table 3

Correlations Between
Locus of Control, Appearance
Control Beliefs, Depressive
Symptoms, Eating Disorder
Symptoms, and Emotional
Eating

	CDI	ChEAT	EE	ChLOC	AC
CDI		.450*	.530**	.398*	.627**
ChEAT			.498**	-.027	.248
EE				.391*	.269
ChLOC					.146
AC					

3

symptoms, two separate regression analyses were performed. Table 4 shows the results with eating disorder symptoms as the dependent variable and Table 5 shows the results with depressive symptoms as the dependent variable. The results indicate that 43% of the variance in eating disorder symptoms was accounted for by Objectified Body Consciousness. Neither locus of control nor the interaction between OBC and locus of control predicted a significant portion of the variance in eating disorder symptoms. However, the variation in eating disorder symptoms accounted for by OBC alone was still 43% and significant after the interaction was entered into the equation. The portion of the variance in depressive symptoms predicted by

locus of control was 39% and significant. When the interaction between locus of control and objectified body consciousness was entered into the equation, it did not predict a significant portion of the variance in depressive symptoms. However, locus of control alone still contributed to 37% of the variance and was marginally significant.

Discussion

The aim of this study was to determine the usefulness of the OBC model in accounting for eating disorder and depressive symptoms in adolescent girls as well as to determine if control beliefs could explain why some girls develop eating disorder

Table 4

Coefficients for Multiple Regression of OBC and Locus of Control on Eating Disorder Symptoms

Variable	<i>b</i>	<i>SE b</i>	β	significance
Model 1				
Step 1 Zscore (OBC Total)	-3.23	1.36	-.430	.026*
Step 2 Zscore (ChLOC Total)	-.875	1.36	-.117	.526
Model 2				
Step 1 Zscore (OBC Total)	-3.19	1.39	-.427	.030*
Step 2 Zscore (ChLOC Total)	-.793	1.45	-.106	.589
Step 3 Interaction	.316	1.60	.037	.845

Table 5

Coefficients for Multiple Regression of Objectified Body Consciousness and Locus of Control on Depressive Symptoms

Variable	<i>b</i>	<i>SE b</i>	β	significance
Model 1				
Step 1 Zscore (OBC Total)	-.193	1.35	-.026	.887
Step 2 Zscore (ChLOC Total)	-2.88	1.35	.393	.042*
Model 2				
Step 1 Zscore (OBC Total)	-.240	1.38	-.033	.863
Step 2 Zscore (ChLOC Total)	2.71	1.43	.369	.070
Step 3 Interaction	-.661	1.58	-.080	.680

OBC = Objectified Body Consciousness Scale

ChLOC = Locus of Control Scale for Children

Correlations marked with an asterisk (*) were significant at $p < .05$.

symptoms and others develop depressive symptoms. High Objectified Body Consciousness was associated with greater endorsement of eating disorder symptoms, providing support for Frederickson and Roberts' (1997) assertion that high OBC is a significant risk factor for eating disorders. Number of eating disorder symptoms endorsed by girls in this study was positively associated with number of depressive symptoms endorsed, supporting prior research findings that depression and eating disorders are often comorbid (e.g., Hudson, Hiripi, Pope, & Kessler, 2007; Jordan et al., 2008). Contrary to the hypothesis, there was no significant association between Objectified Body Consciousness and depressive symptoms. While unexpected, this finding may suggest that some of

the constructs that make up OBC (e.g. maintaining control over one's weight) are not applicable to the development of depressive symptoms in this age group.

Although external locus of control predicted higher levels of depressive symptoms, contrary to the hypothesis, an internal locus of control was not associated with eating disorder symptoms. There are many possible explanations for this finding. It is possible that believing one has control over body weight and shape would cause adolescent girls to engage in healthy behaviors such as exercise and eating a balanced diet instead of unhealthy behaviors such as disordered eating. The fact that an internal locus of control as assessed by Nowicki and Strickland's (1973) Locus of Control Scale for

Children was not associated with negative outcomes may not be surprising given the nature of the scale items. Most deal with areas where being in control would be positive (e.g., “Are you the kind of person who thinks planning ahead makes things turn out better?”). In addition, Nowicki and Strickland (1973) found that having an internal locus of control on their scale was associated with a variety of positive outcomes, such as popularity. Furthermore, some researchers have begun to look beyond internal attributions as a risk factor. For example, Abramson et al. (1989) deemphasized causal attributions in their theory of hopelessness depression, partly because they felt that the impact of assumed negative consequences and negative feelings about the self on the development of feelings of hopelessness were more important than causal beliefs.

Girls who endorsed eating to cope with emotion were also likely to endorse an external locus of control, depressive symptoms, and eating disorder symptoms. These findings suggest that using food as an emotion regulation strategy could be a risk factor for the development of eating disorder symptoms in adolescent girls with depression. Indeed, researchers have found ample evidence for the relationship between depression and binge eating as well as the connection between eating to cope with emotion and binge eating (e.g., Stice et al., 2002). Girls who are depressed may eat to deal with their depressive symptoms and the out-of-control feelings that result from possessing an external locus of control. This could put them at risk for the development of eating disorder symptoms. Longitudinal studies should be conducted to assess whether girls who endorse an external locus of control, depressive symptoms, and eating to cope with emotions eventually develop eating disorders.

One of the limitations of this study is that its findings are correlational; therefore causal inferences cannot be made. It may be, for instance, that an external locus of control in the appearance domain does not increase depressive symptoms, but rather that depression may increase girls' tendency to

believe that they are unable to change their bodies. Future research should use longitudinal studies in order to look for causal relationships between appearance-control beliefs, emotional eating, and depressive symptoms and provide further support for the connections found here. Experimental studies that manipulate mood and body image and then assess control beliefs could also be used.

Another limitation of this study is the small sample size. It is possible that with a larger adolescent sample, there would have been greater variance in depressive symptoms. It could also be the case that high Objectified Body Consciousness is more strongly associated with depression in girls experiencing more severe symptoms. Furthermore, it is possible that there would have been more symptoms in an older adolescent sample. Girls' increased risk for depression develops throughout adolescence (Hyde et al., 2008) but the participants in the present sample were only beginning adolescence. Future studies might use larger sample sizes and a wider range of ages to further examine the relationships between OBC, eating disorders, depression, and control beliefs.

By the end of adolescence, girls are twice as likely to be depressed as boys, a gender difference that will last throughout the lifespan (Hyde et al., 2008). Clinical eating disorders, subclinical disordered eating symptoms, and body dissatisfaction also disproportionately affect adolescent girls. Understanding the risk factors for these disorders is crucial for prevention and treatment. In order to decrease the rates of adolescent girls suffering from these problems, OBC should be dealt with through interventions that help girls to resist internalizing our society's objectification of the female body. These interventions should also address locus of control and emotional eating by helping girls to increase their feelings of self-efficacy and learn functional emotion regulation skills. These interventions could greatly increase quality of life for adolescent girls, allowing them to mature without the burden of damaging and long lasting mental health problems. ■

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Overlooked and Under-Diagnosed: Distinct Expression of Asperger's Syndrome in Females

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There exists a significant gender gap in both referral and diagnosis of Asperger's Syndrome. While the male to female prevalence ratio of autism spectrum disorders is approximately 4:1, the ratio for Asperger's Syndrome is closer to 10:1, prompting calls to understand the cause of this disparity. Clinical accounts provide mounting evidence to suggest that the female expression is subtler and somewhat distinct from the prototypical perception of the disorder. Specifically, females' nurturing peer groups, circumscribed interests seemingly aligned with typical behavior, decreased propensities for aggression, and sophisticated masking abilities may allow patients to escape notice. In addition, Asperger's comorbidity with psychiatric conditions such as depression and anxiety that are generally associated with females may confound clinicians' ability to detect the disorder. Thus, it is suggested that considerable numbers of females with Asperger's Syndrome are being overlooked and thereby not receiving treatment. Further research is recommended to create a more comprehensive characterization of the female phenotype, with the aim of improving accuracy of diagnoses and developing treatments tailored to females' specific needs.

Introduction

Asperger's Syndrome (AS) is an autism spectrum disorder (ASD) of early childhood characterized by impaired social interactions, communication deficits, and isolated interests. A diagnosis of AS made in accordance with the criteria listed in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) encompasses six features: 1) presence of severe and sustained social impairment; 2) presence of restricted and repetitive behavior; 3) significant impairment in functioning; 4) no significant language delays; 5) no significant delays in development of cognition, self-help abilities, or adaptive behavior; 6) criteria are not met for any other Pervasive Developmental Disorder (PDD) or for Schizophrenia (American Psychiatric Association [DSM-IV-TR], 2000). Gillberg's criteria for diagnosis include the additional feature of motor clumsiness (Gillberg, 1991).

While classical autism usually manifests itself before the age of three, AS tends to become apparent during pre-school age, with the majority of cases diagnosed at an age of at least seven (Gillberg & Gillberg, 1989). Many patients have average to above average intellectual abilities, and often there is an increased likelihood to seek social companionship despite a lack of understanding of appropriate social behavior (Khouzam, El-Gabalawi, Pirwani, & Priest, 2004). Some researchers suggest that AS is indistinguishable from High Functioning Autism (HFA) (Freeman, 2002; Volkmar, 2001); others draw the distinctions that AS involves reduced severity of social and communication impairment, increased motor clumsiness, increased early attachment to family

members, a verbal IQ exceeding performance IQ, and a more positive prognosis (Gillberg, 1989; Ozonoff & Farham, 1994; Gillberg, Steffenburg, & Schaumann, 1991; Klin & Volkmar, 1997).

An additional distinction is increased likelihood of isolated interests among AS patients. Individuals may be considered "active but odd," with strong desires to learn whatever they can about a particular topic, sometimes becoming obsessed to the extent that they do not wish to speak of anything else (Attwood, 2007). Patients have difficulties engaging in conversations involving reciprocal give-and-take, and they miss the nonverbal cues of their listeners that signal a desire to change topics or to end the conversation. Often becoming extremely knowledgeable about their particular fascinations, they tend to speak in a pedantic manner, earning them the repute of "little professors" (Ghaziuddin & Butler, 1997).

Prevalence rates of AS vary significantly, as a result of disparate sets of diagnostic criteria including the DSM-IV, International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), and Gillberg's criteria. A 2003 review of six epidemiological studies reported prevalence rates ranging from 0.3 to 48.4 per 10,000. In all six studies, however, the prevalence of AS was lower than that of autism, with current estimates stating that autism is five times as prevalent. Therefore, the conservative estimate of autism prevalence at 10 per 10,000 suggests that AS prevalence is approximately two per 10,000 (Fombonne & Tidmarsh, 2003).

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Male vs. Female Demographics

Epidemiological studies have consistently indicated that autism spectrum disorders are more prevalent among males. While male to female ratios vary across investigations, the average ratio is reported to be approximately 3.5 - 4 to 1 (Fombonne & Tidmarsh, 2003). Moreover, no study has found greater numbers of females than males affected with autism (Lord, 1982).

While the higher prevalence of ASD among males is well reported, the underlying cause of the gender gap has yet to be definitively elucidated. Some researchers suggest that the gap mirrors neurological gender differences in typically developing individuals, with accounts of female superiority in language and male superiority in tasks involving visual spatial abilities (Wing, 1981). Another hypothesis is that boys' threshold for expressing the disorder is reduced (Volkmar, Lord, Bailey, Schultz, & Klin, 2004). Skuse (2000) proposes a genetic explanation, suggesting implication of the x chromosome in ASD; thus, girls' possession of a second non-affected chromosome helps mask expression of the phenotype. Baron-Cohen (2002) has proposed the "extreme male brain theory," which asserts that autism is an exaggeration of the typical male brain that emphasizes systemizing over empathizing. The cause of the ASD gender gap remains unsettled in the scientific community.

Similarly, Asperger's Syndrome is clinically and epidemiologically shown to be more prevalent in males. Hans Asperger, the pediatrician who defined AS in 1944, believed that the disorder affected exclusively boys, and one hundred percent of his patients were male (Attwood, 2007). Though females began to be diagnosed in the 1970s, epidemiological studies agree that the disorder affects boys significantly more than girls. In 1978, Wing and Gould reported a male to female ratio of 15:4; in 1979, Wolff and Barlow reported a ratio of 9:1; and in 1993, Ehlers and Gillberg reported a 4:1 ratio, similar to autism. Using the ICD-10 criteria, the World Health Organization (2006) presents the ratio as 8:1. While debate continues, a current

generally accepted ratio for AS is approximately 10:1 (Stanford, 2003).

Diagnosis of AS cannot be determined via a blood test or other definitive technical procedure; rather, it is diagnosed at the discretion of the individual clinician, based on his or her assessment of the patient's communication skills and social development (Tantum, 1991). This results in challenges and inconsistencies in recognizing and diagnosing the disorder. Some clinicians follow the strictest interpretation of the criteria before making a diagnosis, hesitant to proclaim AS without overwhelming, unambiguous exhibition of symptoms. Another problem is that clinicians who have not worked much with the disorder are less likely to recognize it. These diagnosticians may interpret, for example, a patient's forced eye contact or ability to maintain a conversation as typical enough social interaction, thus dismissing AS (Stanford, 2003). In addition, the milestones of social development are less well defined than those of motor and language abilities (Wetherby, 2006); as a result, many clinicians decide to "wait and watch," leading to delayed diagnoses or none altogether. In fact, it is estimated that as many as 50% of children with AS remain undiagnosed and untreated (Szatmari, Archer, Fisman, Streiner, & Wilson, 1995). These diagnostic obstacles, however, would seem to apply equally to males and females. Is this the case?

Some researchers are now saying no. They believe that the lower male-to-female ratios for AS compared to ASD result not from true differences in expression, but rather from biases in perception of the disorder that allow affected females to "slip past the radar" (Attwood, 1998, p. 22). Before a diagnosis can take place, the patient must be referred for evaluation; and studies indicate that boys are referred at a rate ten times higher than that of their female counterparts (Wilkinson, 2008). Girls also tend to be diagnosed at later ages (Goin-Kochel, Mackintosh, & Meyers, 2006). The diagnostic criteria involve the same cutoff scores for both sexes (Steyaert & De la Marche, 2008), yet case studies indicate possible differences in expression between males and females.

In particular, they suggest that the female manifestation of AS is subtler, less well-characterized, and better masked by females' unique coping mechanisms. The outcome, some researchers suggest, is that considerable numbers of girls with AS are being overlooked.

This paper defends this notion, proposing that females are escaping notice in two arenas: referrals and diagnoses. That is, caretakers are less likely to suspect a social disorder, and clinicians are less likely to call it what it is. The implication is delayed diagnosis, or worse—no diagnosis at all. This paper examines several arenas that may confound recognition, namely: peer groups, isolated interests, non-aggressive behavior, camouflage, and comorbidities. As early diagnosis is critical for providing therapeutic interventions to mitigate social deficits and to help AS patients function in daily living, we conclude with a call for increased awareness of the potential problem and a recommendation for further research to better understand the female manifestation of the disorder.

A Note on Evidence

It should be noted here that the conclusions and recommendations in this paper are based primarily on the author's investigation of case studies and clinical accounts. Indeed, no widespread empirical investigation has been conducted to show, definitively, a gender gap in diagnosis. Thus, it is hoped that the evidence presented here will bring attention to a potentially very significant problem that can pave the way for further organized study.

Too Little, Too Late:

Reduced Referrals and Diagnoses

Peer Groups and Imaginary Friends

Many individuals with AS do desire social interaction, even if they have difficulties actually fulfilling these wants in naturalistic settings. The desire for friendship is illustrated in the following case study: "Most of Emma's focus centered on her desire to be social and have friends...[yet] she did not socialize with her peers... appearing to want to engage,

but not knowing how to begin" (Elkis-Abuhoff, 2008, p. 266).

Despite social deficits, a young girl with AS may have an easier time forming friendships than a young boy. This phenomenon, however, is less likely due to the female's superior social intuition than it is the result of natural differences between male and female peer groups. Groups of male children tend to be antagonistic, while groups of girls exhibit a more nurturing character (Sansone & Sansone, 2008). Thus, a boy who does not behave in expected ways is more likely to be mocked or bullied. In Wing's (1981) clinical account, three out of the five males investigated reported victimization: "[Case 1] was much teased at school" (p. 123), "[Case 2] was bullied at school and remembers it as an unhappy time" (p. 124), "[Case 6] is often teased by his classmates" (p. 128). A young boy with AS may then complain to his teacher or parents, alerting caretakers of a potential problem and leading to subsequent referral to a clinician for evaluation and diagnosis (Attwood, 2007).

In contrast, a female who does not fit in with her peers may still develop a close friendship with another girl, with the latter treating the former in a maternal way (Attwood, 2007). That is, as the girl with AS tends to be socially inexperienced, an affectionate friend enjoys "taking care" of her, instructing her on proper behavior. In Wing's clinical account (1981), the only female investigated was, in fact, reported to be "accepted in school" (p. 125). To the teacher or parent's untrained eye, the girl with AS may seem capable of forming friendships; yet in actuality, the relationship may have arisen more from her friend's motherly desire to help a socially awkward peer than from the patient's ability to relate to and befriend another. Since inability to develop typical social relationships is a warning sign for AS, this young girl may escape notice. If and when the girl becomes separated from her maternal friend, however, her social deficits may become clearer, leading to a delayed referral (Attwood, 2006).

In addition, if the female with AS cannot relate to her peers, she may seek social fulfillment with

imaginary friends or dolls. This behavior is often considered normal in young girls. However, the child with AS does not treat her imaginary social world in the same way that typically developing children do. She does not seek reciprocity, but rather behaves in a domineering way; that is, she tries to control rather than engage in her fictional social world (Attwood, 2006). Holliday-Willey exemplifies this phenomenon in her autobiography, *Pretending to be Normal: Living with Asperger's Syndrome* (1999):

Far more interesting to me was the arranging of the supplies. Like with my tea parties, the fun came from setting up and arranging things. Maybe this desire to organize things rather than play with them is the reason I never had a great interest in my peers. They always wanted to use the things I had so carefully arranged. They would want to rearrange and redo. They did not let me control the environment... I much preferred the company of my imaginary friends (p.18).

A similar image is illustrated in Wing's clinical account (1981): "She collected costume dolls, which she arranged in rows that must not be disturbed" (p. 125). A case study by Wilkinson (2008) provides further support: "She typically enjoyed activities such as dressing up, acting out Disney videos, playing with her Barbie dolls, and talking to an imaginary friend" (p. 6). A girl interested in tea parties or dolls, however, does not signal a clear case of atypical behavior and thus may be overlooked by caretakers who do not examine the specific ways in which she engages in her ostensibly normal interests (Attwood, 2006).

Isolated Interests

Individuals with AS often find fascination in specific subjects, known as circumscribed interests (CI). These interests typically increase in intensity over time, and patients may desire to spend the majority of their leisure time ascertaining information about the interest (Boyd, 2007). Among males, common circumscribed interests fall in the

categories of transportation, science, electronics, movies, and music (Shrank-Fernandez, Kuipers, & Katz, 1986). Gillberg's case study (1985) describes a male who "developed a fanatical interest in meteorology and would never miss the weather forecast on the radio" (p. 391). Another account, collected by Stanford (2003), describes a man at a party with his wife's colleagues: "He'd only talk to people about the new handheld device he's working on, then he walked away when people tried to talk back to him" (p. 70).

Girls with AS develop obsessions with a similar degree of intensity, yet these interests tend to differ in content. Clinical testimonies indicate that young girls may become obsessively interested in subjects like animals or dolls (Prior, 2003), while teenage girls often take to classic literature, including poetry and writings of Shakespeare. As Attwood (2006) describes, these forms of literature have an "intrinsic rhythm that they [the patients] find enticing" (p. 5). Clinicians, however, are inclined and trained to think of Asperger's when they see children with encyclopedic knowledge of the prototypical male topics.

In addition, while a common reputation of AS patients is that they are "little professors," Attwood (2007) suggests that females may behave more like "little philosophers" (p. 47). They may evaluate social situations in profoundly intellectual ways, noticing and analyzing incongruities. They may ponder questions such as whether all people see the same color in the same way. They may think up elaborate fantasy worlds. However, parents and teachers tend to interpret such behavior as imaginative rather than indicative of a possible social disorder (Wagner, 2006). As the "little professor" stereotype is the one well-recognized as a potential signal of Asperger's, deviations from that stereotype are likelier to go unnoticed.

Reduced Aggression

Boys with AS who become frustrated in the social world may act out in aggressive ways. Girls, however, are both less hyperactive and less aggressive

than boys (Gillberg & Coleman, 2000), and a female who cannot understand her social domain may avoid it altogether. Hiding her frustrations, she may wander toward the outsides of peer groups and evade participation in school and family functions (Attwood, 2007).

The following is a teacher's account of a young female diagnosed with AS: "In class, she was observed to be a quiet and reserved student who usually stayed on the periphery of the group. She was also described as shy, undemanding... unassuming and soft spoken" (Wilkinson, 2008, p. 4). Here is a report of another female patient who preferred the avoidance approach: "Emma expressed that she has a hard time looking to others for social cues, explaining that she has difficulty interpreting facial expressions, so she avoids looking at faces, or even looking at her own reflection in the mirror" (Elkis-Abuhoff, 2008, p. 268). In contrast, consider this account of a male adolescent with AS: "He assaulted a crying child on a railway station by putting his hands over its mouth to stop its noise" (Mawson, Grounds, & Tantam, 1985, p. 567). While it would be incorrect to generalize that all male patients express their frustrations through aggression, as some prefer evasion as well, reports suggest that, overall, males tend toward this coping mechanism more than their female counterparts (Gillberg & Coleman, 2000).

The aggressive reaction is difficult to ignore, raising suspicion of a social disorder and thereby leading to referral (Kopp & Gillberg, 1992). In fact, children are rarely referred for evaluation as a result of observed social or communicative impairment; rather, referrals tend to stem from observations of hyperactivity, physical aggression, or "bizarre behavior" (Ghaziuddin, 2002, p. 138). Reduced expression of these salient warning signs in females may lead teachers and parents to overlook problematic behavior. The female reaction to frustration may be mistakenly interpreted as shyness and ignored. That is, reclusive girls with AS may be accepted as "shy," "naïve," or "sweet," rather than pegged as socially impaired (Wagner, 2006, p. 20-21).

Camouflage

A patient in a perplexing social situation has an additional option beyond aggression or avoidance: camouflage of social deficits through masking mechanisms. Attwood (2006) suggests that girls with AS may contribute to making their own diagnoses difficult in that they tend to be more motivated than their male counterparts to hide their impairment. Cognizant of the importance of social interaction—even if they are not skillful in it themselves—girls may investigate in a systematic and intellectual manner the proper ways to behave and then attempt to copy them. As a result, they may exhibit seemingly appropriate behavior—achieved, however, not through instinct or automatic social learning, but through contrived imitation without underlying understanding (Attwood, 2006).

As an example, Attwood (2007) describes the trajectory of a girl with AS approaching a novel social situation. Initially, she does not understand the rules of group behavior. Fearful of making a social gaffe, she therefore "politely declines" to join the group and remains on the periphery, where she vigilantly observes and memorizes others' speech and actions (p. 46). Only then does she join her peers. On a broader scale, she may even memorize scripts of key phrases that she finds can apply across many situations. Holliday-Willey demonstrates this approach in her autobiography:

I often found it desirable to become the other person. Not that I consciously set out to do that, rather it came as something I simply did... At times I literally copied someone's looks and their actions. I was uncanny in my ability to copy accents, vocal inflections, facial expressions, hand movements, gaits, and tiny gestures. It was as if I became the person I was emulating (p. 26-27).

This phenomenon then poses a controversial question for the female patient who uses camouflage as a coping mechanism. According to the DSM-IV's third criterion for diagnosing AS, the condition must cause significant detriments in functioning (DSM-IV-TR, 2000). If the patient can

effectively hide her social deficits, imitating to the point that she can function in her social circle, does she even have a disorder?

A defense of her condition's validity is the notion that imitation allows for unhindered functioning only in familiar, rehearsed environments. That is, without the natural ability to determine appropriate social behavior, a patient is not equipped to adapt to her surroundings. As Attwood (2007) writes, "If the rules or nature of the game suddenly changes, the child is lost" (p. 46). The use of simple mimicry cannot provide sustained efficacy in the realities of the social world, in which rules do constantly change and the ability to modify behavior accordingly is necessary. Thus, it seems that sophisticated camouflaging ability is not sufficient grounds for dismissal of the disorder.

Comorbidities Predominant in Females

The final area of analysis, comorbidities typically associated with females, is distinct from the others in that it does not involve gender differences in phenotypic expression of AS. Rather, it suggests that the demographics of related psychiatric conditions may obscure clinicians' ability to recognize the disorder. As such, while the other factors may lead to biases in both referrals and diagnoses, the comorbidity factor would lead only to bias in diagnoses.

Asperger's Syndrome has high comorbidity with other psychiatric disorders, with studies suggesting that comorbidity is present in more cases of AS than it is absent (Gillberg & Billstedt, 2000). One clinical investigation revealed that 65% of those AS patients evaluated had a comorbid psychiatric disorder (Ghaziuddin, Weidmer-Mikhail, & Ghaziuddin, 1998). These conditions include anxiety, depression, anorexia, schizophrenia, obsessive compulsive disorder (OCD), attention-deficit hyperactivity disorder (ADHD), bipolar disorder, sleep disorders, and Tourette's Syndrome (Ghaziuddin, 2002).

The clinical study by Ghaziuddin et al., (1998) reported that the most prevalent comorbidity was depression, and other investigations have confirmed that mood disorders—namely depression

and anxiety—are the most common comorbid conditions (Howlin, 1997). In AS patients the depression often stems from a recognition of the importance of social skills combined with an awareness that they do not fit in with their peers (Ghaziuddin, 2002). In one case study reported by Wing (1981), a patient's depression escalated to the point that he attempted suicide: "[The patient] blamed himself for all his problems, describing himself as an unpleasant person, whom no one could like and who could not manage his own life" (p. 121). In fact, Gillberg (2002) suggests that depression is "probably the most common erroneous diagnosis in Asperger's syndrome" (p. 50).

Depression on the whole, however, is more common among females; epidemiological studies estimate that the condition is twice as prevalent in women (Wilhelm, Roy, Mitchell, Brownhill, & Parker, 2002). Numerous studies have agreed that females are more susceptible to the stresses leading to the condition and are more likely to exhibit symptoms (Ge & Conger, 2003). In particular, depression tends to be associated with female adolescents (Nolen-Hoeksema, Larson, & Grayson, 1999). As a result, when a child or teenage girl shows symptoms of depression or anxiety, a comorbid AS may be missed.

That is not to suggest, of course, that patients who are diagnosed with depression should automatically be searched for Asperger's as well. While depression is highly comorbid with AS, the relationship is not necessarily reciprocal (that is, many individuals with AS have depression; but many individuals with depression do not have AS). Thus, it is recommended that a clinician perform a comprehensive examination and have a familiarity with the particular cues that may in fact indicate an underlying social disorder. While this recommendation applies to both male and female patients, it is particularly important in the latter case where depression is more prevalent and thereby a more routine endpoint for diagnosis. One clinical study recounted that the majority of its female Asperger's patients were diagnosed with anxiety or another mood disorder before the AS was determined (Bashe &

Kirby, 2005).

Another masking comorbidity is anorexia. Nearly one quarter of all girls with anorexia nervosa show symptoms of AS. These individuals may refuse food because of hypersensitivity to certain tastes, textures, colors, or smells, or because of strict adherence particular food preparation routines (Bogdashina, 2005). Yet, with anorexia up to three times as common in females than males (Carter, Stewart, & Fairburn, 2001), a clinician's focus on the diagnosis of anorexia may conceal its underlying relation to AS (Attwood, 2007).

Consequences: No Diagnosis, No Treatment

Though there is no cure for AS, there exist many options for treatment that lead to a better prognosis. In early childhood, children begin to face new situations in which they must learn to get along with other children, teachers, and staff members, and it has been shown that educational and behavioral therapies can help AS patients acclimate to their changing communities (Khouzam et al., 2004). Adolescence poses even greater challenges, as teenagers must deal with the onset of puberty and a social environment that tends to place even greater emphasis on assimilating with peers (Wing, 1981). Interventions during this stage of development are critical in helping patients foster the skills needed to engage in their environments and to cope with academic and social stresses. Finally, the skills garnered during adolescence ease the transition into adulthood, helping patients achieve independent living and success in social, scholastic, and vocational realms (Ryan, 1992; Khouzam et al., 2004).

As diagnosis is the first step towards treatment, individuals who escape diagnosis cannot receive the therapies they need, which encompass educational and behavioral supports, psychotherapy, and psychopharmacology (Khouzam et al., 2004). Clinical investigations have shown that delayed diagnosis in females is linked to social isolation, diminished academic performance, and an even greater risk for developing anxiety or depression (Wilkinson, 2008). In addition, untreated females may be increasingly

vulnerable to sexual abuse due to their naïveté and inability to read nonverbal cues (Attwood, 2007).

Conclusions

The gender gap in Asperger's Syndrome is a relatively new and weakly researched phenomenon, with potential explanations based more on sporadic compilation of case studies than on empirical epidemiological investigations (Wilkinson, 2008). While there is no consensus that females are being overlooked, information from clinical accounts seems to provide substantial enough evidence to warrant further investigation of the subject. Case studies suggest that AS may express itself differently in girls and boys, and our current, ingrained perception of the Asperger's patient—namely, a socially inept but often extremely knowledgeable “little professor,” who speaks pedantically about science and technology, who is often bullied, and who expresses his frustrations through aggression—may hold less accurate for the female with AS. Comorbid conditions that are generally more expected in females may also confound proper diagnosis.

It follows that a comprehensive, detailed characterization of the female phenotype is greatly needed. With further research into gender-specific variations in expression, diagnosticians can subsequently be trained to recognize subtler and perhaps less archetypal manifestations of the disorder. Moreover, an improved understanding of the female phenotype may allow for the development of increasingly effective therapies. Treatment currently considered successful is based on research with mostly male subjects; and if females manifest AS differently, the techniques that work in boys may be less successful in girls. Just as patients with AS express the disorder differently, based on disparate personalities, tendencies, and interests, so must the therapy cater to individual differences in order to achieve maximal effectiveness (Williams, 1995; Khouzam et al., 2004). As such, it is suggested that substantial further research into the female manifestation of AS is essential for diagnostic and treatment purposes. ■

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Integration: Serotonergic and Dopaminergic Pathways Implicated in the Development and Maintenance of Behaviors in Restricting-Type Anorexia Nervosa

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Anorexia nervosa has one of the highest mortality rates of all mental illnesses (National Eating Disorders Association, 2006a). Elucidating the neurobiological basis of the disorder would be a major step toward understanding it. By integrating findings from research into depression, anxiety, and eating disorders, the present paper introduces a possible neurological mechanism that contributes to the development of anorexia nervosa. In this model, the neurological dysfunctions that underlie anorexia can be described as disturbances in excitatory and inhibitory projections to the amygdala instigated by increased dopamine and unbalanced serotonin activity. By further exploring these unique disturbances, clinicians and researchers will be able to improve prognosis and treatment.

Introduction

Anorexia nervosa (AN) is a devastating illness with debilitating and sometimes irreversible physical and psychological consequences. Core features of the disorder include: fear of food and weight gain, anhedonia (the decreased experience of pleasure), dysphoria, body image distortion, repetitive behavior, and perfectionism (Kaye et al., 2005; Kaye, 2008). Denial of illness is common; relapse and mortality rates are high (Kaye et al., 2005; National Eating Disorders Association, 2006a; Kaye, 2008). Despite this troubling situation, there is only limited experimental research on therapies for AN, very little of which has found adequate empirical support (Wilson, Grilo, & Vitousek, 2007). In fact, chronic anorexia nervosa cases are often extremely resistant to treatment (Wilson, Grilo, and Vitousek, 2007). Surely a more nuanced understanding of the disorder would facilitate the development of more effective and long-lasting therapeutic results. As such, this paper seeks to establish a neurological model of restricting-type anorexia nervosa (RAN) that may shed light on its etiology and possible targets for treatment.

Though little is known about the neurobiological bases of AN, other diseases that are commonly comorbid with AN have been researched in considerable depth; thus, examining AN from the perspective of these disorders could enable researchers to elucidate common neurobiological factors that may account for their comorbidity, and in course, central aspects of AN that may impact treatment. AN is often comorbid with obsessive compulsive disorder (OCD) and depression (Deep, Nagy, Weltzin,

& Rao 1995; Kaye, 2008), and genetic overlaps have been found as well (Bellodi et al., 2001). The disorder also shows strong comorbidity with dependent, avoidant, and obsessive-compulsive personality disorders, which are classified as “anxious-fearful” (Cassin & von Ranson, 2005). Most importantly, anxiety, depression, and maladaptive personality traits often predate the onset of anorexia, and may even be predisposing factors (Deep et al., 1995). Finally, probands (genetic forbearers) of anorectic subjects have been found to have higher rates of anxiety disorders than control probands, suggesting common genetic and/or neurological bases (Strober, Freeman, Lampert, & Diamond, 2007).

Researchers have suggested that similarities between AN and anxiety and depression-related disorders may be due to early, possibly genetically-linked disturbances in serotonin (5-HT) and dopamine (DA) functioning. In AN, environmental factors related to food and body image could precipitate the use of disturbed eating as a coping mechanism for neurological disturbances and related negative affective symptoms (Kaye et al., 2003, 2005; Kaye, 2008). Starvation may improve mood through decreased tryptophan intake, a precursor to serotonin (Kaye et al., 2003, 2005; Kaye, 2008). Food consumption is also directly related to the release of DA in the brain (Bosanac, Norman, Burrows, & Beumont, 2005; Frank et al., 2005; Kaye, Frank, & McConaha, 1999). Thus, individuals may turn to starvation as an effective method of altering whatever neurological dysfunction has contributed to aversive emotional states.

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The association between anxiety and anorexia is particularly noteworthy. The term anorexia nervosa literally means “lack of appetite induced by nervousness.” Disturbances that are highly associated with anorexia, including obsessionality, perfectionism, anhedonia, behavioral inhibition, and high harm avoidance, are behavioral expressions of anxiousness (Kaye et al., 2005; Garakani, 2006). Furthermore, anorexia is highly associated with disproportionate negative affect. In fact, von Ranson and Woodside (2005) found that as negative affect increases so too does food restriction, while chances of recovery weaken. Thus, symptoms of anxiety and depression may contribute to the development of AN.

Given this background, the current paper attempts to integrate evidence from research on depression, anxiety, and eating disorders (EDs) to describe a possible framework for understanding the neurological mechanisms underlying restricting-type anorexia nervosa (RAN)¹. The components of the proposed model follow:

1. A genetic predisposition to disrupted serotonin (5-HT) activity will lead to deficits in executive functioning and elevated baseline anxiety levels, leading to high levels of harm avoidance, behavioral inhibition, and rigidity.
2. Abnormal 5-HT activity also causes a deregulation of the mesolimbic (composed of emotional brain regions) and mesocortical (composed of cortical brain regions) DA systems. In response to reduced inhibition from the mesocortical DA system, mesolimbic DA activity will increase. This will decrease reward sensitivity in the nucleus

1 This paper will focus primarily on findings about restricting-type anorexia nervosa. Restricting-type anorexia nervosa (RAN) is a subtype of anorexia nervosa, which is characterized by the maintenance of extremely low weight and persistent restriction of caloric intake. It is distinct from binge/purge anorexia nervosa, which is characterized by maintenance of low weight, as well as episodes of bingeing and purging. Elucidating this distinction is not the objective of this paper, but the particular behavioral and neurological differences found between bingeing disorders and RAN provide insight into the unique neuro-behavioral manifestations of the disorder.

accumbens, a region of the ventral striatum, leading to decreased motivation and reward responsiveness. Furthermore, increased DA and decreased 5-HT activity in the anterior cingulate cortex (ACC) will inhibit this region, leading to a deregulation of the amygdala and a compromised ability to extinguish learned fear associations.

While research has looked at the nature of the relationships between AN, depression, and anxiety, too few studies have applied knowledge of the neural bases of depression and anxiety to AN. This paper will therefore use current knowledge of limbic and cortical dysfunction in abnormal emotional processing to conceptualize possible mechanisms for the development of RAN.

Cortical and Subcortical Dysfunction in Depression and Anxiety

Mood and anxiety disorders have been associated with dysfunction in the amygdala (AMG), a subcortical brain region located in the medial temporal cortex that plays a crucial role in the detection of threatening stimuli (Davidson, 2002). It has been found to be hyperactive in patients suffering from depression, and a number of anxiety disorders including OCD, specific phobias, post-traumatic stress disorder, and panic disorder (Davidson, 2002; LaBar & Cabeza, 2006). The amygdala plays a large role in anxiety because it is recruited in both the acquisition and expression of fear conditioning (Garakani et al., 2006; LaBar & Cabeza, 2006). Studies have found that in anxiety disorders, exaggerated amygdala activity mediates the formation of associations between neutral stimuli and conditioned fear responses (Garakani et al., 2006; LaBar & Cabeza, 2006; van den Heuvel et al., 2004).

While the amygdala records and expresses fear associations, the left prefrontal cortex (PFC) extinguishes them, most likely by inhibiting AMG activity. The medial PFC has been found to inhibit the firing of amygdala neurons, and in rats with medial PFC damage, fear extinction was significantly slower than in healthy controls (Garakani et al., 2006; Davidson, 2002). Furthermore, higher reported

levels of negative affect in subjects were correlated with lower relative resting left PFC activity and/or right amygdala hyperactivity (Davidson, 2002). In the case of RAN, a disruption in the relationship between the AMG and the PFC may be taking place, leading to the appraisal of food as threatening.

The relationship between the AMG and the anterior cingulate cortex (ACC) provides another key to understanding the phenomenology of anxiety. Correlated activity has been demonstrated between the AMG and two regions of the perigenual ACC (pACC): a positive correlation between the AMG and the rostral subgenual ACC (rACC), and a negative correlation between the AMG and the caudal supragenual ACC (cACC) (Pezawas et al., 2005). A positive correlation between the rACC and cACC suggests a possible feedback loop between the three regions. Together, the distinct regions of pACC modulate AMG activity, while also promoting each other's required levels of activation. In subjects with the s allele (a serotonin transporter polymorphism related to depression and anxiety), disruption of this feedback loop was found, which was characterized by reduced AMG-rACC functional connectivity (Pezawas et al., 2005). Furthermore, the nature of this relationship accounted for 30% of the variance in harm avoidance scores, a trait strongly related to both anxiety and AN (Pezawas et al., 2005).

In sum, neurobiological factors that contribute to anxiety may also contribute to the anxious characteristics of AN (Pezawas et al., 2005). Anxious feelings and behaviors can potentially be caused or facilitated by a disruption in the relationship between the mPFC and/or the pACC and the amygdala. And as the following section will show, neuroimaging studies enable further insight into the roles of serotonin (5-HT) and dopamine (DA) in AMG modulation and consequently in the behavioral manifestations of RAN.

Neurobiological Models of Anorexia Nervosa

Dopamine

Dysfunctional dopamine activity has been found in RAN subjects (Kaye et al., 1998, 2005; Frank et al.,

2005; Casper, 2006; Davis & Woodside, 2002; Bosanac et al., 2005), which provides strong explanatory power for crucial behavioral manifestations of the illness, such as motivational disruptions, hyperactivity, anhedonia, excessive exercise, low novelty seeking, and withdrawal from food. Specific brain regions affected by dysfunctional dopamine activity include the striatum, prefrontal cortex (PFC), anterior cingulate cortex (ACC), and amygdala (AMG).

There are two major dopamine pathways in the brain, the mesolimbic and mesocortical pathways. The mesocortical dopamine pathway is formed by projections from the ventral tegmental area (VTA) to the neocortex (including the PFC), while the mesolimbic dopamine pathway is formed by projections from the VTA to regions of the limbic system (including the striatum, ACC, and AMG) (Masciotra, Landreau, Conesa, & Erausquin, 2005). Findings in schizophrenic subjects indicate that DA activity levels in these two pathways are functionally inversely related: inhibiting the mesocortical pathway leads to enhanced synaptic responsiveness in the mesolimbic pathway (Masciotra et al., 2005). Such dysfunction could potentially play a role in anhedonia and depression, symptoms common to both schizophrenia and RAN, and thus could potentially be extended to theories of RAN.

Evidence exists for increased DA activity in the mesolimbic pathway. Research examining recovered anorectic subjects has shown decreased cerebrospinal fluid (CSF) concentrations of homovanillic acid, a major metabolite of DA (Kaye et al., 1998, 2005; Frank et al., 2005; Casper, 2006; Davis & Woodside, 2002; Bosanac et al., 2005). This supports increased DA receptor activity, as decreased concentrations of DA metabolites in CSF provide positive feedback to receptors, up-regulating their activity to ensure efficient use of limited DA (Frank et al., 2005). Furthermore, increased binding potential of DA receptors has been found in recovered RAN subjects in the striatum, a subcortical brain region central to reward, motivation, movement, and learning processes, and a portion of which is a

component of the mesolimbic DA pathway (Frank et al., 2005; Pierce & Kumaresan, 2006).

Although there is no evidence of a disruption in the mesocortical pathway in RAN, the model of mesolimbic-mesocortical interaction (i.e., the functional inverse activation relationship) indicates that mesocortical activity would be reduced. Increased mesolimbic and decreased mesocortical DA activity could lead to anorectic behaviors through maladaptive reward responsiveness and fear conditioning: receptor insensitivity has been found to promote extreme motivation for future over immediate reward (e.g., denying immediate gratification of hunger for future achievement of the “perfect” body) (Frank et al., 2005; Kaye et al., 1999, 2005, 2008; Casper, 2007).

As mentioned earlier, the AMG is recruited in the acquisition and expression of fear associations, and is regulated by the ACC and the PFC. Research has shown that DA can inhibit ACC activity, thus leading to AMG hyperactivity (Holroyd & Coles, 2002). In addition, since the mesocortical pathway is made up of DA tracts in cortical regions of the brain, decreased activity in mesocortical tracts may lead to decreased activity of the PFC, which may also contribute to AMG hyperactivity. These findings suggest that elevated DA may lead to reduced extinction of aversive conditioned associations, leading RAN patients to appraise food as threatening.

While binge-eating disorder and bulimia nervosa (BN) subjects show decreased DA receptor binding as compared with control groups (Frank et al., 2005), RAN, on the other hand, is characterized by a strong withdrawal relationship with food, suggesting a converse effect of DA receptor activity. High levels of DA in areas like the antero-ventral striatum, which includes the nucleus accumbens, a critical component of reward anticipation, may lead to reduced sensitivity to external rewards such as food, making it easier for anorectics to withdraw from food (Davis & Woodside, 2002; Kaye et al., 2003). In addition, increased DA activation may lead to a decreased sensitivity to and need for novel

experiences (Kaye et al., 1999, 2008; Kandel et al., 2000). This behavior also differs between anorectics and bulimics, the latter exhibiting high impulsivity and novelty seeking behavior (Thompson-Brenner et al., 2008).

Furthermore, if DA levels were elevated in anorexia, the risk of substance abuse would be lower, as many drugs are DA agonists. In fact, research has shown a lower frequency of substance abuse in RAN, in contrast to bulimia and AN binge-purge subtype (Deep et al., 1995; Kaye et al., 2005; Kaye, 2008; Thompson-Brenner et al., 2008). Additionally, DA agonists suppress appetite, further suggesting that high levels of dopamine inhibit feeding behavior (Frank et al., 2005). Thus it can be postulated that high DA levels in RAN are associated with decreased reward sensitivity, appetite, and approach behavior. These deficits most likely result from increased mesolimbic DA activity, as regions central to reward responsiveness reside in the limbic brain.

While hyperactivity is not a diagnostic criterion for anorexia nervosa, it is a characteristic that has been highly associated with the disorder, and has even been suggested as an addition to the next version of the Diagnostic and Statistical Manual for Mental Disorders (Davis & Woodside, 2002; Casper, 2006). In addition to excessive exercise, RAN is typified by general hyperactivity, including repetitive movement. Research has suggested that the hyperactivity seen in RAN may be in part due to increased DA activity in the striatum (Frank et al., 2005; Kaye et al., 1999, 2005, 2008; Casper, 2007). DA has also been implicated in motor control, and has been shown to play a role in displays of stereotyped (i.e., repetitive) behaviors in animals, which is analogous to hyperactivity in anorexia (Kaye et al., 1999).

Increased DA activity may also contribute to anhedonia in RAN patients. Davis and Woodside (2002) found that non-exercising anorectics had the highest anhedonia (the decreased ability to experience pleasure) scores among excessive and nonexcessive exercising anorectics, bulimics, and recovered anorectics. Exercise down-regulates DA activity, suggesting that in RAN

Table 1

Consequences
of elevated
DA activity
in RAN

Mesolimbic DA pathway	Behavioral Consequences	Mesocortical	Behavioral Consequences
Striatum – nucleus accumbens	Reward responsiveness Anhedonia Excessive exercise Motivation (long over short term rewards) Stereotyped movement Low novelty seeking Withdrawal from food/reduced hunger	Prefrontal cortex	Inhibited – reduced extinction of learned fear associations
ACC	Inhibited		
Amygdala	Excited		

physical hyperactivity may regulate DA hyperactivity (Davis & Woodside, 2002). Thus, physical hyperactivity may serve to reduce anhedonia by decreasing excessive DA. Excessive activity may also reduce other DA-related symptoms such as anxiety. Decreased reward responsiveness has also been associated with decreased mesocortical DA activity in depression (i.e., anhedonia), furthering the evidence for increased mesolimbic DA and, by extension, decreased reward responsiveness in RAN (Holroyd & Coles, 2002). Thus, anhedonia and hyperactivity may be associated with a disruption in both the mesocortical and mesolimbic dopamine pathways (See Table 1).

In sum, research points to dysfunctional DA activity in RAN patients. Increased mesolimbic DA activity may contribute to decreased reward sensitivity, leading to withdrawal from food and increased hyperactivity, while decreased mesocortical DA activity may contribute to an appraisal of food as threatening.

Serotonin

A number of behavioral manifestations of RAN can be explained by abnormal serotonin (5-HT) activity, namely harm avoidance, behavioral

inhibition, rigidity, and withdrawal from food (Bailer et al., 2005; Kaye et al., 2005). Crucially, 5-HT receptor balance plays a role in the modulation of DA activity (Kaye et al., 2002). Thus, the DA dysfunction seen in RAN could be explained by upstream effects of 5-HT. Specific brain regions that may be affected by disrupted serotonin activity in RAN are the ACC, AMG, and frontal and temporal cortices.

The exact nature of 5-HT dysfunction in RAN is somewhat more contentious than that of DA disruption. Some research has shown differences in serotonin levels between ill and recovered RAN subjects, with recovered women showing reduced 5-HT_{2A} binding potential in the entire neocortex and cingulate cortex, but normal activity in 5-HT_{1A} receptors (Audendart et al., 2003; Bailer et al., 2005), and ill women showing elevated 5-HT_{1A} and normal 5-HT_{2A} receptor binding activity (Bailer et al., 2007). However, a number of studies have found no differences between ill and recovered subjects in dysfunctional 5-HT receptor imbalance (Bailer et al., 2004, 2005, 2007).

Further contributing to the controversy, it is not clear what imbalances may exist before and/or following chronic starvation (Kaye et al., 2005a, b;

Bailer et al., 2005, 2007; Audendart et al., 2002; Bosanac et al., 2005; Casper, 2006). It is thus difficult to conclude from current evidence whether restriction in fact alters brain chemistry to the extent that serotonin abnormalities are actually ameliorated. However, strong biological evidence supports the notion that diet affects serotonin availability (Kaye et al., 2003, 2005; Kaye, 2008). It is possible that the brains of restricting anorexics are able to return to “normal” activity after a time even in the face of starvation, creating a vicious cycle of using transiently effective restriction to ameliorate consistently returning aversive emotional states.

In multiple studies of RAN subjects, 5-HT activity has been positively correlated with harm avoidance (HA), a trait found to be significantly elevated in anorexia (Bailer et al., 2005; Kaye et al., 2005). Furthermore, 5-HT receptor activity in the periaqueductal gray, a region with connections to the ACC, has been associated with the modulation of escape behavior, a measure of anxiety, in rats (Bailer et al., 2005). It is possible that the ACC is affected by 5-HT imbalances in humans as well, which could have implications for AMG activity, for which the ACC is an important modulator (Pezawas et al., 2005). High levels of anxiety (characterized in part by HA) in humans may thus be potentiated by an imbalance in 5-HT receptor activity that inhibits ACC function and subsequently enhances amygdala activity. Elevated 5-HT activity seems likely in this case, considering the positive association found between serotonin and HA (Bailer et al., 2005; Kaye et al., 2005). Reduced tryptophan (a precursor to 5-HT) intake through restriction would presumably reduce 5-HT availability and activity, leading to reduced HA and anxiety.

Cognitive and behavioral rigidity (resistance to changing beliefs, activities, and actions; commonly conceptualized as a deficit in problem-solving relating to an over-reliance on previous experience) are evidenced in RAN patients by their seemingly compulsive adherence to dieting patterns, and their dysfunctional and rigid core beliefs about themselves, others, and their illness (Bailer et al., 2005). It

is highly probable that behavioral persistence and denial of illness would be caused or reinforced by such deficits. These traits may be promoted by the hyperpolarization of pyramidal cells in the frontal lobes precipitated by abnormal 5-HT activity, leading to severe disruptions in learning new information, activating memories, and regulating behavior in accordance with salient stimuli (Kaye et al., 2005). In healthy women, 5-HT receptor balance has also been found to contribute to modulating behavioral inhibition, further supporting a role of serotonin in decision-making (Bailer et al., 2005).

Serotonin is also implicated in satiety. Food related stimuli have been shown to activate the ACC and the anteromedial temporal cortex in healthy individuals, regions with disrupted 5-HT activity in anorectic patients (Bailer et al., 2005). These regions and others may be desensitized to hedonic stimuli such as food, which, along with DA-induced motivational disruptions, would facilitate withdrawal behavior. In addition, Drive for Thinness, a measure of dysfunctional motivation in eating disorders, has been significantly inversely related to 5-HT_{2A} receptor activity (Kaye et al., 2005). This supports the finding from neuroimaging studies that 5-HT_{2A} receptor activity is reduced in RAN patients (Audendart et al., 2003; Bailer et al., 2005).

Thus, 5-HT has been found to be associated with elevated harm avoidance, behavioral and cognitive rigidity, behavioral inhibition, withdrawal behavior from food, and a drive for thinness, symptoms highly characteristic of restricting anorexics. Like DA, abnormalities in both cortical (e.g., frontal and temporal cortices) and limbic regions (e.g., ACC, AMG) of the brain may contribute to these maladaptive behaviors (Bailer et al., 2005; Kaye et al., 2005), though evidence suggests that 5-HT receptor activity may be reduced, elevated or imbalanced depending on the brain region that is affected (Table 2).

The Anxious-Anorectic Model

According to this proposed model, genetic variations may contribute to a disruption in serotonin

Table 2

Consequences
of abnormal 5-HT
activity in RAN

Limbic Regions	Behavioral Consequences	Cortical Regions	Cortical Regions	Abnormal Activity in Unknown Regions
ACC: Inhibited	Harm avoidance (elevated 5-HT) Withdrawal behavior from food (abnormal 5HT, possibly elevated)	Frontal cortex	Rigidity: behavioral persistence, denial of illness	Behavioral inhibition (receptor imbalance)
Amygdala: Excited by ACC inhibition and directly by 5-HT	Harm avoidance	Temporal cortex	Withdrawal behavior from food	Drive for thinness (reduced 5-HT-2A receptor activity)

activity. In response to 5-HT dysregulation, the mesocortical DA system would be inhibited, leading to reduced activation in the PFC. In addition to causing deficits in executive functioning, this diminished activation would lead to decreased extinction of conditioned fear responses (Davidson, 2002). An amplification of conditioned fear would intensify anxiety, harm avoidance, and hypervigilance toward neutral stimuli such as food².

As a consequence of reduced mesocortical activity, the mesolimbic DA pathway would become hyperactive, leading to increased DA activity in the striatum and the amygdala. This would in turn contribute to the reduced reward responsiveness and deficient motivation seen in anorectic patients. ACC activity would also be inhibited by elevated DA activity, leading to learning deficits (e.g., rigidity), and weakened amygdala inhibition. Decreased 5-HT levels in the ACC may furthermore directly contribute to weak modulation of the amygdala. This would contribute to an exaggerated amygdala response to emotional stimuli, and may lead to increased feelings of threat³.

Future Directions

The model proposed in this paper brings together previously disparate empirical research on brain systems whose functions and patterns of

correlation with behavioral symptoms suggest that they may be important in understanding the neural bases of restricting-type anorexia nervosa. Since little research has focused on this topic, this model is a first step. Future research must test its claims empirically before it can be considered validated.

Specific claims amenable to experimental testing include: (1) that ill, recovered and at-risk RAN populations will show elevated DA activity in mesolimbic brain regions (e.g., ACC, amygdala and ventral striatum), and reduced DA activity in mesocortical regions (e.g., frontal and parietal cortical regions); (2) that these populations will show imbalanced 5-HT activity most likely characterized by reduced 5-HT activity in some regions (i.e.,

² Many RAN subjects display increased anxiety in the face of other neutral stimuli, but food may take center stage primarily because of the very strong interactions between food, 5-HT, and DA (e.g., tryptophan as a precursor for 5-HT, food's role in DA potentiation). When combined with sociocultural and environmental factors (e.g., teasing about weight, media preoccupation with thinness), these relationships may lead some women to rely on extreme dieting as a coping mechanism for aversive emotional states.

³ According to this model, along with food and weight-related sociocultural factors as well as the direct associations between food and these neurotransmitters, higher levels of baseline anxiety would precipitate the use of dietary restriction as a method for coping with negative emotional states.

ACC), and elevated activity in others (i.e., frontal lobes); (3) that these brain abnormalities will be altered by starvation (though possibly only in the short term); and (4) That the level of abnormal 5-HT and DA activation will be statistically related to certain behavioral traits characteristic of RAN (e.g., 5-HT with harm avoidance, behavioral inhibition, rigidity, withdrawal behavior; and DA with hyperactivity/excessive exercise, reduced reward responsiveness, disrupted motivation).

In light of all this, future research should focus on elucidating the exact nature of serotonin disruption, as well as the relationship between serotonin and dopamine pathways. Research with depressed patients, in which dopamine levels are examined before and after selective serotonin reuptake inhibitor therapy could prove quite helpful. Furthermore, research within anorectic subjects should specifically examine distinct dopamine pathways, brain regions, and stages of illness to determine if neurotransmitter disruption is affected by drug therapy.

Despite the connections made between depression, anxiety, and anorexia, it is important not to assume that they are the same illness. One arena in which this is crucial is treatment. A common treatment for both anorexia nervosa and depression today is the administration of selective serotonin reuptake inhibitors, which increase serotonin activity. However, as the evidence shows, the exact nature of 5-HT disruption in AN is not yet clear. In addition, the particular disruptions in brain activity may differ from region to region. Thus, globally increasing serotonin activity may in fact exacerbate neurological and behavioral disturbances, for example by increasing serotonin activity in regions

in which reduced activity is preferable (e.g., the ACC). It is clear then that medical therapies for anorexia must be targeted to the particular neurological manifestations of the illness. Researching and developing these types of therapies, based on a clearer understanding of the underlying neural blueprint of the disease, would have the potential to vastly improve treatment outcomes.

Conclusion

This paper has attempted to show that distinct models of anxiety and depression can be combined with personality and behavioral understandings of anorexia nervosa to elucidate the mechanisms of each illness, and to create a very strong neurological model of anorexia. To reiterate, this model proposes a genetic predisposition to disrupted serotonin activity that causes a deregulation of the mesolimbic and mesocortical DA systems. Decreased mesocortical DA activity reduces PFC functioning, leading to deficits in executive functioning, as well as reduced fear extinction by way of decreased amygdala inhibition. In response to reduced inhibition from the mesocortical DA system, mesolimbic DA activity will increase. This decreases reward sensitivity in the nucleus accumbens, leading to decreased motivation and reward responsiveness, and may overstimulate the amygdala, potentially causing an exaggerated response to emotional stimuli. Furthermore, increased DA and decreased 5-HT activity in the ACC will inhibit this region, leading to a deregulation of the amygdala, and subsequently to increased activation in response to threatening stimuli. ■

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Environmental Enrichment Contributes to Neurodevelopmental Recovery After Hypoxia

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Premature, very low birth weight infants often suffer from hypoxia, a deficiency of oxygen that can result in lasting cognitive and behavioral impairments. The present study used a mouse model to explore hypoxia-induced neurodevelopmental deficits and the role of environmental enrichment in reducing these abnormalities. It was found that chronic neonatal hypoxia decreased parvalbumin-expressing cortical interneurons and impaired spatial memory. However, hypoxia-reared mice that were environmentally enriched had greater cortical volumes than those that were not, and their parvalbumin-expressing interneuron number and spatial memory task performance were not different from controls. These findings suggest that low oxygen levels significantly alter brain cellular composition, neurotransmitter levels, volume, and function. Environmental enrichment may be a critical factor in reducing hypoxia-induced effects.

Introduction

Neurodevelopment can be drastically affected in infants born preterm (before 37 weeks) with very low birth weight (VLBW) (less than 1500 g; Aylward, 2002). Major disabilities such as moderate to severe mental retardation, sensorineural hearing loss or blindness, cerebral palsy, and epilepsy occur in 12 to 14% of this population. However, high prevalence, low severity dysfunctions—such as learning disabilities and borderline mental retardation—occur in 50 to 70% of preterm VLBW infants (Aylward, 2002). During school-age years, preterm VLBW children demonstrate significantly lower cognitive scores and are more likely to suffer from neuropsychological deficits when compared to normal-birthweight children (Bhutta et al., 2002). Behavioral handicaps such as attention deficit hyperactivity disorder (ADHD), increased externalization and internalization of behaviors, and depression are observed more often in premature VLBW children than in their normal-birthweight counterparts (Bhutta et al., 2002; Rääkkönen et al., 2008; Sommerfelt et al., 1993).

Abnormal development of lung tissue and bronchopulmonary dysplasia are complications in preterm VLBW infants which result in chronic hypoxemia, a condition of decreased oxygen carriage in the blood (Fagel et al., 2006; Hack et al., 2002; Ment et al., 1998). Low oxygen may be a key instigator in the mental and behavioral disabilities mentioned above (Fagel et al., 2006; Hack et al., 2002). A mouse model of chronic perinatal hypoxia has been developed to investigate hypoxemia and to manifest the neurodevelopmental patterns of preterm

VLBW infants (Fagel et al., 2006; Ment et al., 1998). Even though preterm VLBW infants exhibit cognitive and psychological disabilities early in life, these handicaps often decrease with age, indicating that some mechanism(s) occurs in the developing brain to reduce hypoxia-induced deficits (Fagel et al., 2006; Ment et al., 2003). One mechanism through which this recovery may occur is cortical neurogenesis, or the development of new neurons in the brain. Even after birth, a small number of neurons are generated in the juvenile and adult brain, especially following injury (Fagel et al., 2006; Magavi et al., 2000). Previous research has shown that increased cortical neurogenesis can occur after a period of hypoxia to reverse the effects of low perinatal oxygen levels, including loss of cortical neurons, cortical volume, and brain weight (Fagel et al., 2006).

In addition to cortical neurogenesis, another mechanism that may serve to compensate for hypoxia-induced effects is environmental enrichment, which has the potential to produce significant cellular, molecular, and behavioral changes in the brain (Praag et al., 2000). An enriched environment is a setting that facilitates inanimate and social interactions, increases physical activity, and stimulates sensory and motor pathways. In animal models, such a setting is created by introducing items such as a larger cage, exercise equipment, larger groups of individuals, toys, nesting materials, and tunnels. The experimental setting may be altered by frequently replacing toys and changing food locations to ensure novelty and stimulation (Mora et

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al., 2007; Praag et al., 2000). Enrichment can induce neural plasticity, thus contributing to neurodevelopmental recovery in damaged or diseased brains (Praag et al., 2000). For example, enrichment drastically improves cognitive functions such as learning and memory, an effect that correlates with the positive effects caused by an increase in neurogenesis (Mora et al., 2007; Segovia et al., 2009). Similar to the effects of cortical neurogenesis, normal rodents placed in enrichment manifest increased brain weight and size (Fagel et al., 2006; Praag et al., 2000).

It seems possible, then, that environmental enrichment may also facilitate the recovery from neurodevelopmental deficits in the mouse brain after chronic perinatal hypoxia. The purpose of the present research was to determine the consequences of chronic sublethal perinatal hypoxia on gamma-aminobutyric acid (GABA)ergic interneuron development and spatial memory, and to explore environmental enrichment as a possible mechanism of recovery after the hypoxic insult. We found that cortical interneurons exhibit significant deficits of the calcium-binding protein parvalbumin (PV) after hypoxia. However, this strong effect on hypoxia-reared mice disappears if they are placed into environmental enrichment; in fact, levels of cortical PV-positive interneurons and cortical volume were not significantly different in hypoxic, enriched mice, and normoxic mice. Data gathered from two behavioral tests, the Delayed-Alternation task and Morris water maze, also indicate that enrichment can eliminate spatial memory impairments that result from chronic perinatal hypoxia.

Because the mouse model of hypoxia parallels the neurodevelopmental patterns of preterm VLBW infants, these findings as well as this entire line of research are relevant to clinical human therapies. By understanding how low oxygen levels affect brain chemistry and cellular composition, and by discovering enrichment conditions that reverse these effects, we may understand how environmental alterations and therapies may be used to improve the cognitive, behavioral, and psychological well-being of individuals born preterm

with VLBW. Furthermore, this study elaborates upon disruptions in GABAergic interneuron development, a phenomenon that is characteristic of a spectrum of illnesses such as epilepsy, schizophrenia, autism, Tourette's, anxiety disorders, and more (Kalanithi et al., 2005; Levitt, 2005). By studying the role and importance of GABAergic interneurons in early development, we may gain more knowledge of many developmental disorders and the mechanisms by which they act.

Materials & Methods

Animals

All procedures in these experiments were approved by the Yale Animal Resources Center and Institutional Animal Care and Use Committee (IACUC). Animals in the behavioral studies were standard C57B mice; animals in the stereological studies were transgenic GAD67-GFP mice. In the latter cohort, green fluorescent protein (GFP) was transcribed under the promoter for the glutamate decarboxylase isoform 67 gene (GAD67-GFP). Upon birth, mice were randomly assigned to one of four experimental conditions: normoxic, non-enriched (NX/NE); normoxic, enriched (NX/E); hypoxic, non-enriched (HX/NE); and hypoxic, enriched (HX/E).

Rearing in Hypoxia and Enrichment

Mice in the hypoxic conditions were placed in an airtight Plexiglas chamber with a continuous flow of air with O₂ displaced by N₂; the overall concentration of O₂ was 9.5 to 10.5%. Oxygen levels were monitored minute-to-minute by sensors coupled to a computer. For all analyses, the period of hypoxia began at postnatal Day 3 (P3) and continued for eight days to P11. Hypoxic chambers were inspected twice daily to ensure appropriate oxygen levels.

Mice in the enrichment conditions were placed into large Plexiglas cages measuring 24 cm wide × 20 cm high × 46 cm long. A running wheel, a series of clear and colored plastic "habit-trails" of different configurations, and several small plastic, hard rubber, or wooden balls and objects

of different shapes were scattered on the cage floor. Small wooden blocks or metal link chains were suspended from the cage roof. Every three days, objects were changed, cleaned, disinfected, and rearranged to ensure novelty. Prior to weaning, 5 to 13 pups were housed per cage. After weaning and gender separation, no more than eight pups were housed per cage. Enrichment cages were inspected twice daily. The enrichment period began at P20 and continued until immunohistochemical examination or behavioral testing. Mice not in the enrichment conditions were housed in standard rack mount Plexiglas cages measuring 18 cm wide × 13 cm high × 29 cm long. The bottoms of all enriched and non-enriched cages were lined with pine shavings. All mice were exposed to a 12:12-hour light-dark cycle and were provided ad-libitum access to water and food. Prior to weaning, food was located on the cage floor; after weaning, food was provided via a wire bar cage-top food hopper. Cages were changed weekly, and infant mortality, maternal cannibalism, and other health and well-being issues were addressed in a timely manner.

Immunohistochemistry

At P47, animals intended for immunohistochemical analysis were deeply anesthetized with a ketamine-xylazine injection and perfused transcardially with 10 mL of 0.01 M Phosphate Buffered Saline (PBS) and 35 mL of 4% paraformaldehyde (PFA). Brains were dissected from the skull, post-fixed in PFA for 24 hours, and cryoprotected in a 20% sucrose solution for 24 hours. The brains were then embedded in 4% agarose gel for vibratome sectioning or optimal cutting temperature compound for cryostat sectioning and stored at -80 °C. Brains were serially sectioned either coronally or sagittally at 50 µm thickness with a Leica VT 1000S vibratome at room temperature or Leica CM1900 at -20° C. Free-floating sections were stored at +4°C in a 0.04% sodium azide (NaN₃/PBS) solution until subsequent staining.

Sections were washed in PBS and blocked in a 0.1% Tween-20 / 0.2% Triton-X solution

containing 10% normal goat serum (NGS/PBS++). They were incubated overnight in primary antibodies in 5% NGS / PBS++ at +4°C. Primary antibodies included mouse anti-PV (1:2500 or 1:1000, Sigma); rabbit anti-GFP (1:1000, Abcam); and chicken anti-GFP (1:2000, Abcam). After primary antibody incubation, sections were washed three times with PBS and incubated for 1 hour in secondary antibodies in 5% NGS / PBS++ at room temperature. Secondary reagents included goat anti-mouse Alexa 594 (1:1000 or 1:500, Invitrogen); goat anti-rabbit Alexa 488 (1:1000, Invitrogen); and goat anti-chicken Alexa 488 (1:500, Invitrogen). Sections were washed in PBS, mounted, and coverslipped using Vectashield mounting medium with DAPI (4', 6-diamidino-2-phenylindole) (Vector, Burlingame, CA).

Stereology and Cell Counting

Stereological analysis was completed using the StereoInvestigator software and a Zeiss Axioskope 2 Mot Plus equipped with a motorized stage, coupled to a computer. Contours of cerebral cortex and basal ganglia (counted as a whole region including the striatum, nucleus accumbens, and globus pallidus) were delineated with visual aid of DAPI and reference to The Mouse Brain in Stereotaxic Coordinates. StereoInvestigator software allowed for systematic, random sampling for cell counts using the optical fractionator method. Cells positive for PV were visualized by a 594 nm filter, GFP was visualized by a 488 nm filter, and DAPI was visualized by a 350 nm filter. Cells were counted using a three-dimensional 100 × 100 × 5 µm counting frame in a sampling grid of 1000 × 1000 µm or 700 × 700 µm for cortex and 300 × 300 µm for basal ganglia. Approximately 101 sampling sites in each coronally sectioned cortex, 200 sites in each sagittally sectioned cortical hemisphere, and 78 sites in basal ganglia were counted.

A Y-maze with three identical arms was used in the Delayed-Alternation (DA) spatial memory task, which took place starting between P45 and P60 (Figure 1A). During the training period, each animal was placed at the start arm and allowed to choose a

Figure 1

Spatial Memory Tasks

A. Delayed-Alternation spatial memory task
 B. Morris water maze. Start indicates start position of each trial. Choice indicates two possible paths; dark gray square represents small chocolate reinforcements in choice arms; light gray square represents alternate baiting; Target indicates target quadrant; small circle represents hidden platform.

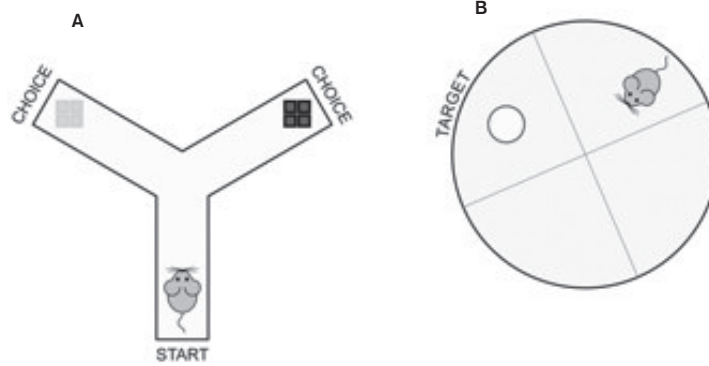
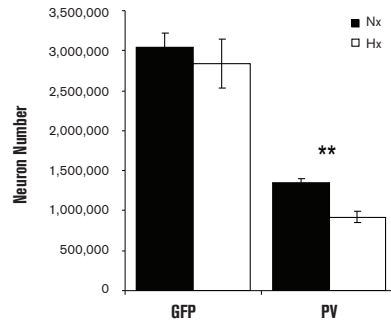


Figure 2

Mice Reared in Hypoxia Exhibit 32% Fewer GABAergic Interneurons Expressing PV

Hx mice were exposed to chronic sublethal hypoxia from postnatal Day 3 (P3) to P11. Nx, normoxia; Hx, hypoxia; GFP; green fluorescent protein; PV, parvalbumin.

**P < 0.01, comparing Nx versus Hx by t-test.

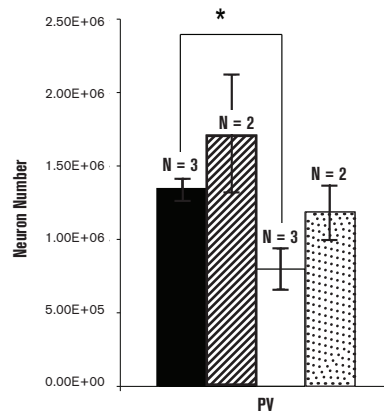


Nx = normoxia
 Hx = hypoxia
 NE = non-enriched
 E = enriched
 PV = parvalbumin
 *P < 0.05, t test.

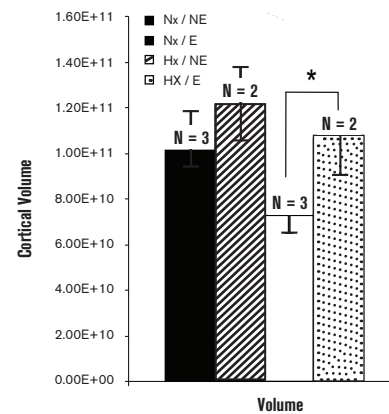
Figure 3

Even Though Hypoxia Induces Negative Effects in the Mouse Cortex, Compensation Can Occur by Enrichment

A. Number of PV+ cortical interneurons
 B. Volume of cortex (μm³). Hx mice were exposed to chronic sublethal hypoxia during postnatal Day 3 (P3) to P11. E mice were reared in environmentally enriched cages from P20 to P47.



A



B

Table 1

Total Number of Neurons of the Indicated Phenotype as Assessed by Stereological Analysis

Hx mice were reared in chronic sublethal hypoxia from postnatal Day 3 (P3) to P11. % indicates the percent difference between Hx and Nx mice.

	Normoxia		Hypoxia		%
	N =	Total Cell Number	N =	Total Cell Number	
Cerebral cortex					
GFP	4	3,035,926	3	2,837,059	NS
PV**	3	1,347,712	3	921,998	-32**
Basal ganglia					
GFP	3	619,377	3	673,908	NS
PV	3	1,371	3	2,157	NS

Nx = normoxia; Hx = hypoxia; GFP = green fluorescent protein; PV = parvalbumin.

** P < 0.01, NS, not significant, comparing Nx versus Hx by t test.

path to one of two choice arms, where small chocolate reinforcements were placed. Then animals rested for an inter-trial interval. Successful learning of the task required selection of the choice arm that was not selected on the previous reinforced trial. After the initial placement of reinforcements in both arms, only the choice arm opposite the previous choice arm was baited. Animals participated in this training for ten trials per day until they accomplished the criterion performance of 80% correct choices over two consecutive days. Mice that successfully completed the 80% correct choices criterion were tested again using the next higher inter-trial delay period; these were 25 s, 1 min, and 5 min. In scenarios in which an animal did not reach criterion performance before 200 trials at a particular delay period, testing was terminated.

The circular Morris water maze was 1.5 m in diameter and filled with opaque water (Figure 1B). Testing took place between three to five months of age. Animals were allowed four trials per day for eight days to swim to a transparent Plexiglas platform hidden within a consistent target quadrant of the plastic tub beneath the water's surface. Path and time to reach the platform was monitored by a video tracking system (Coulbourn Instruments, Inc.). On Days 9, 16, and 23 of testing, probe trials of 60 s were completed in which the hidden platform

was removed. Total path length and percent time in the target quadrant were calculated from the video tracking system data. The probe preference (PP) score, which demonstrates the time spent in the target quadrant relative to the time in the other three quadrants, was also calculated.

Statistics

In the comparison of normoxia and hypoxia, p values were calculated using Student's t-test. Comparisons of select means of the four normoxia and hypoxia, non-enriched and enriched conditions were also calculated similarly. In the DA spatial memory task, data were analyzed using a Survival Analysis test. In the eight-day training period of the Morris water maze as well as the probe trial, comparisons between the four conditions and time to reach the platform were analyzed using a repeated measures multivariate analysis of variance test (MANOVA). A post-hoc comparison using the Scheffe test was also completed for these data.

Results

Hypoxia-Reared Mice Exhibit Fewer Parvalbumin-positive Interneurons in the Cortex

To compare the potential for inhibitory neurotransmission in hypoxia- and normoxia-reared animals,

GFP+ interneurons were analyzed in the cerebral cortex and basal ganglia. Total cortical GFP+ cell numbers were similar in all mice, regardless of oxygen rearing, which suggests that GABAergic neuron number is not affected by hypoxia (Figure 2, Table 1). This finding indicates that the potential for inhibitory control is present; however, a neurodevelopmental mechanism hinders the function of GABAergic neurons. Therefore, PV+ cells (a subset of GABAergic interneurons) were examined. Despite no difference in GFP+ cells, PV+ cortical GABAergic interneurons of HX mice were significantly decreased by 32%, an absolute number of approximately 425,000 cells in total, compared to NX mice ($p < .01$) (Figure 2, Table 1). The number of GFP+ and PV+ neurons in the basal ganglia of the NX and HX conditions did not differ significantly (Table 1).

Hypoxia-Reared Mice Exhibit Decreased Performance in the Delayed-Alternation Task

To assess the effect of oxygen rearing on spatial memory, a DA task was performed. With a short 25s inter-trial delay, HX and NX mice were no different in number of trials required to achieve criterion performance or number of mice that failed the task before 200 trials (Table 2). With a 1-min inter-trial delay, no HX mice failed the task; however, they did take significantly more trials to succeed at the task than controls ($p < .05$) (Table 2). With a long 5-min inter-trial delay, HX mice again required more trials to reach criterion performance and also failed the DA task significantly more often than NX mice ($p < .05$) (Table 2).

Enrichment After Hypoxia Increases Cortical Volume and Parvalbumin-Positive Cells

With the knowledge that hypoxia induced cortical PV+ interneuron and spatial memory deficits, we investigated the effects of environmental enrichment on interneurons. As previously observed, HX / NE mice exhibited a decrease in the number of cortical PV+ interneurons by approximately 547,000 cells in total ($p < .05$) (Table 3, Figure 3A). However, HX / E animals did not exhibit this effect;

the cortical PV+ neuron number of HX / E mice did not differ significantly from controls (Table 3, Figure 3A). The cortices of HX / NE mice showed a trend to be of smaller volume than NX / NE mice, but the result was not significant (Figure 3B). The effect of enrichment in HX mice was significant, however, as cortical volume of HX / E mice was 32% greater than that of HX / NE mice ($p < .05$) (Figure 3B). This compensation of the HX-induced deficit, similar to the effect on PV+ cells, was enough to make the difference between HX / E and NX / NE cortical volumes not significant (Table 3, Figure 3B).

Environmental Enrichment After Hypoxia

Improves Performance in the Morris Water Maze

To determine whether environmental enrichment induced a recovery in spatial memory similar to the recovery in PV+ cell number, a Morris water maze was conducted. No statistically significant differences in time for animals to reach the hidden platform were detected among the four conditions during the training period (Figure 4). To assess the strength of learning, further analysis was completed for the 60 s probe trial conducted on Day 9. Information from the video data tracking system demonstrated that NX mice swam in the target quadrant where the platform had been removed more than HX mice, which lacked this preference and instead swam at the edges of the tub (Figure 5). In an analysis of all four conditions, significant differences were found for the percent time in the target quadrant ($F(3, 44) = 8.2$; $p = .001$) and for the probe preference (PP) score ($F(3, 44) = 6.6$; $p = .001$) (Figure 6A, B). NX / NE mice spent significantly less time in the target quadrant (16.6% less, $p < .001$) and had a significantly lower PP score (12.3 less, $p < .001$) than mice in the other three conditions (Figure 6A, B). No significant difference was found among groups in total distance traveled (Figure 6C).

Discussion

Hypoxia induces neurodevelopmental deficits but enrichment can reduce these effects. The calcium-

Table 2

Mice Reared in Hypoxia Experience Deficits in Spatial Memory Retention During the Delayed-Alternation Task

Hypoxic mice were reared in chronic sublethal hypoxia from postnatal Day 3 (P3) to P11. DA testing began between P45 and P60. Failed indicates the number of mice not reaching criterion performance before 200 trials. Trials indicates the mean trials to reach criterion performance.

	N =	Failed	Trials	Logrank p value
25 second delay				
Normoxia	13	0	64	p = 0.8388
Hypoxia	11	0	71	
1 minute delay				
Normoxia	13	0	51	p = 0.0485*
Hypoxia	11	0	110	
5 minute delay				
Normoxia	13	4	119	p = 0.0218*
Hypoxia	11	8	180	

*P < 0.05, comparing Normoxia versus Hypoxia by t-test.

binding protein PV, expressed in approximately half of cortical GABAergic neurons, allows for fast-spiking transmissions that modulate synaptic activity, affect glutamate levels, and regulate overall neural function (Chow et al., 1999; Woo & Lu, 2006). Established studies suggest that neurological and behavioral impairments caused by abnormal GABAergic neuron development can be considerable if they occur in early embryonic or postnatal periods (Levitt, 2005; Woo & Lu, 2006). The present research emphasizes the importance of GABAergic interneuron development by demonstrating that a short-term insult by hypoxia at a critical period of development can drastically alter the circuitry of the mouse brain and can result in permanent defects observable near adulthood. HX and NX mice demonstrated similar numbers of GABAergic interneurons that were positive for GAD67-GFP, suggesting that GABAergic interneurons retained the potential for inhibitory neurotransmission. However, the fact that the number of GABAergic interneurons that expressed PV was decreased in HX mice indicates a deficit in the function of inhibitory neural control. Thus, the cortical PV+ cell data suggest that

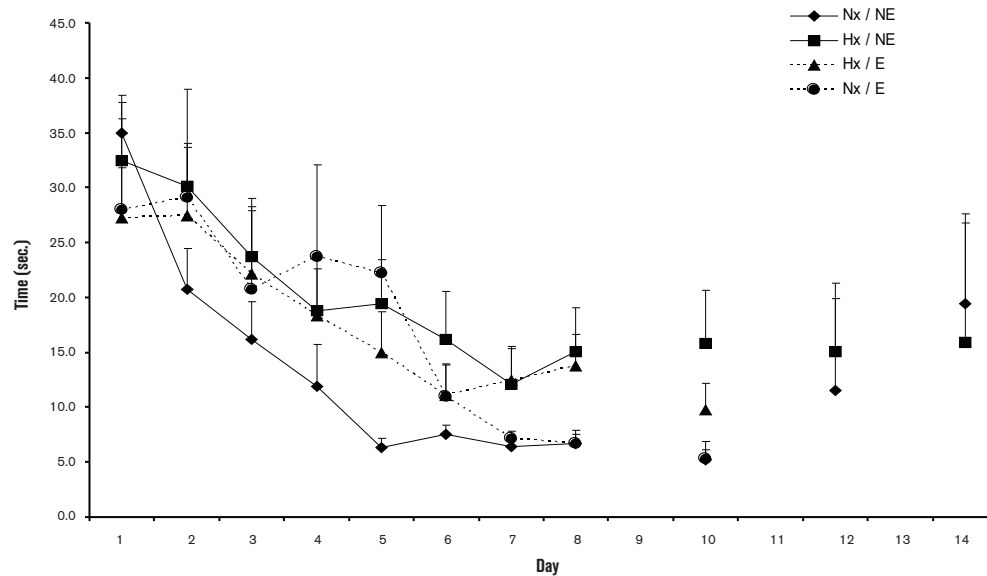
a neurodevelopmental mechanism that affects GABAergic interneuron function is dependent on perinatal oxygen levels.

Chronic perinatal hypoxia decreased the number of cortical PV+ GABAergic cells by almost one-third ($p < .01$) (Table 1, Figure 2). This abnormality could conceivably alter cortical synchronous oscillatory activity and impair behavior in individuals such as preterm VLBW infants (Lodge et al., 2009). Previous research has shown that cortical PV+ cell number is inversely correlated with hyperactivity (Smith et al., 2007). Additionally, our preliminary behavioral findings reveal hypoxia causes transient hyperactivity from age P16 to P18. Our animal model may accurately portray the development of preterm VLBW individuals, since hyperactivity disorders such as ADHD more frequently occur in this population than in children of normal birth time and weight (Bhutta et al., 2002; Sommerfelt et al., 1993). The fact that GAD67-GFP+ GABAergic cell number was not different between NX and HX mice suggests that the number of neurons with GAD67 message may be normal, even though the GAD67 protein may still be decreased. However, there is clearly a

Figure 4

Performance in the Morris Water Maze as Indicated by Time to Platform

Hx mice were reared in chronic sublethal hypoxia from postnatal Day 3 (P3) to P11. E mice were reared in environmentally enriched cages from P20 until testing between 3-5 months of age. After eight days of training, probe trials took place on Days 9, 16, and 23.



phenomenon that limits GABAergic interneuron development, since HX brains have decreased cortical PV+ GABAergic interneuron number.

In future studies, other markers of PV interneuron development may be investigated. For example, decreases in neurotrophins such as brain-derived neurotrophic factor (BDNF) or ion channels such as potassium-chloride cotransporter KCC2 or voltage-gated potassium channel KV3.1b may be mechanisms that explain decreased PV+ cell numbers. Lower levels of these chemicals may hinder dendritic arborization, synapse formation, postsynaptic inhibitory potential, or fast-spiking ability of interneurons (Gulyás et al., 2001; Woo & Lu, 2006).

Preterm VLBW infants experience motor impairments ranging from motor difficulties or developmental coordination disorder to cerebral palsy (Schmidhauser et al., 2006). Even though mice in the HX condition experienced a PV+ neuron deficit in the cortex, no such effect was observed in the basal ganglia. Therefore, the circuitry of the cortex and basal ganglia are fundamentally different and the effects of hypoxia on each brain region may

differ. For example, motor deficits due to hypoxia may not be affected at the primitive level of the basal ganglia, but may occur instead at the higher processing controls in the cerebral cortex.

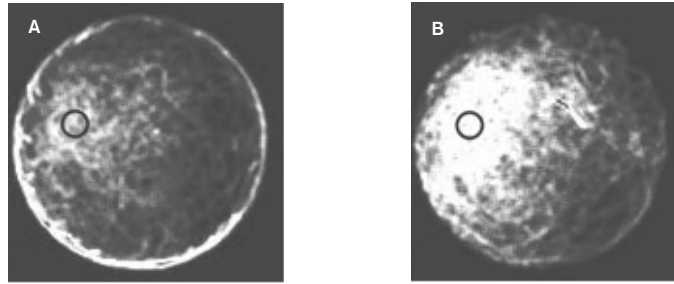
Interestingly, the number of PV+ cells of HX mice that were placed into environmental enrichment were not significantly different than number of cells of NX mice (Figure 3, Table 3). This result suggests that even though chronic perinatal hypoxia induced PV+ cell deficits, a stimulating environment is sufficient to reverse the negative effects of the insult. One mechanism of PV+ cell number enhancement by enrichment may be increased neurotrophins, which increase in cortex and other brain regions with long-term environmental enrichment (Ickes et al., 2000). There was also a trend for the PV+ neuron number to be higher in HX / E than in HX / NE, and higher in NX / E than in NX / NE (Figure 3A, Table 3). With the addition of more animals into the experiment, statistical significance may be achieved.

Another trend observed in this study was decreased cortical volumes of HX mice when compared to NX controls (Figure 3, Table 3). Such a loss

Figure 5

Video Data Tracking of Morris Water Maze Probe Trial

View of Morris water maze from above. Circles indicate hidden platform in target quadrant. Lighter shades of gray indicate longer amounts of time spent in a particular location in the maze.



A. Hypoxia

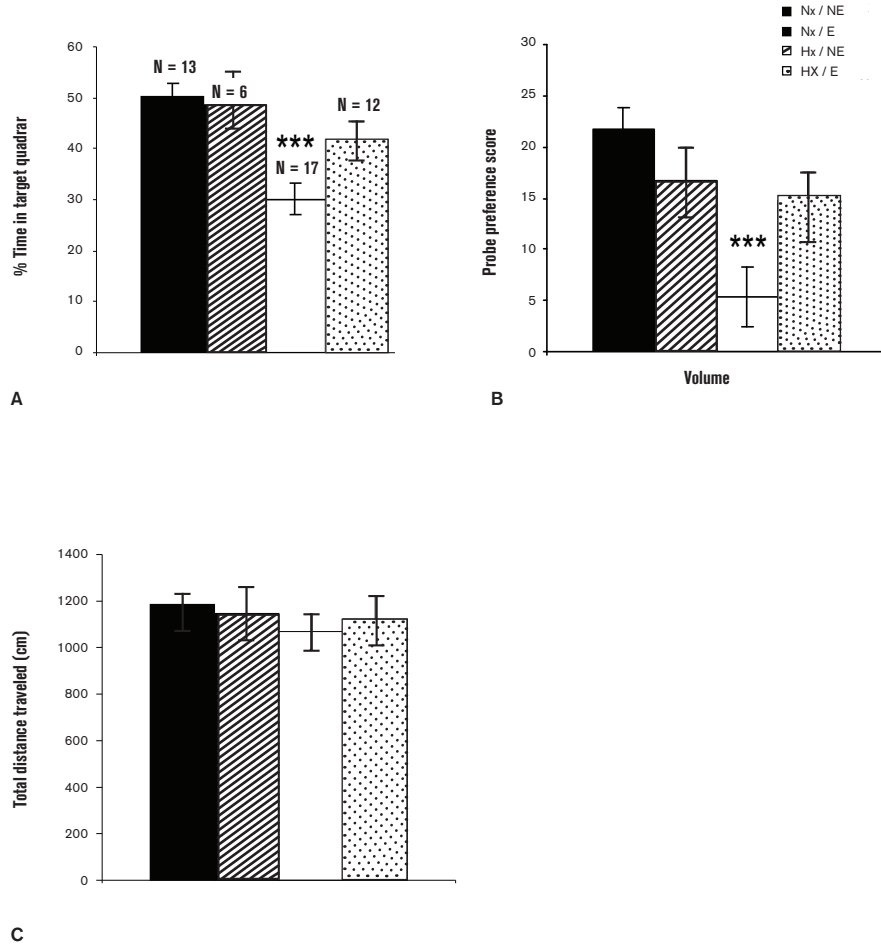
B. Normoxia. Hypoxic mice were reared in chronic sublethal hypoxia from postnatal Day 3 (P3) to P11. Testing took place between 3 and 5 months of age. After an eight-day training period, this 60 s probe trial took place on Day 9.

Figure 6

Hx / NE mice perform worse in the Morris water maze than Hx / E and control mice.

A. % time in target quadrant
 B. Probe preference score
 C. Total distance traveled. Hx mice were reared in chronic sublethal hypoxia from postnatal Day 3 (P3) to P11. E mice were reared in environmentally enriched cages from P20 until testing between 3 and 5 months of age. After the training period, this 60 s probe trial took place on Day 9.

Nx = normoxia
 Hx = hypoxia
 NE = non-enriched
 E = enriched
 ***p < 0.001, MANOVA



in cortical volume may be attributed to smaller cell size and may decrease efficiency in neural communication. However, the cortical volume decrease between HX mice and NX controls was not seen when HX mice were placed into enrichment. Environmental enrichment after hypoxia rearing significantly increased cortical volume ($p < .05$) (Figure 3, Table 3). The reversal of the deficits caused by hypoxic insult was sufficient to bring the cortical volume of HX / E mice to that of controls, since differences in the cortical volumes of these groups were not significant (Figure 3, Table 3).

Behavioral Data Parallel Stereological Findings

The stereological findings of hypoxia-induced deficits and enrichment-facilitated recovery correspond with behavioral testing of spatial memory. In the Y-maze DA task, mice performed similarly with a short 25 s delay, regardless of the oxygen levels in which they were reared (Table 2). This finding suggests that hypoxia does not affect initial spatial learning, and short-term spatial memory is preserved. However, with an increased 1 min delay HX mice required more trials to succeed at the task ($p < .05$), and with a long 5 min delay HX mice required more trials and failed more often ($p < 0.05$) (Table 2). The declining performance in the DA task as inter-trial interval lengthened indicates that even though spatial learning and memory formation is intact, the HX animals' ability to retain these spatial memories over time is impaired.

In the Morris water maze training, differences in time to the hidden platform and distance traveled were not significant among HX and NX animals; therefore spatial learning and memory formation did occur (Figure 4). However, in later probe trials which assessed the animals' strength of learning, NX mice exhibited a preference for the target quadrant from training, as indicated by video tracking data, percent time in the target quadrant ($p < 0.001$), and PP score ($p < 0.001$) (Figure 5, 6A, and 6B). The fact that HX mice have a decreased strength of learning parallels the learning deficits found in preterm VLBW school-aged children. These individuals

have IQ scores that are 12 to 14 points below normal birth weight children, and more than 50% of these individuals require special assistance in education (Aylward, 2002).

The DA task and Morris water maze revealed that spatial learning strength and memory retention are limited by hypoxia, but initial learning and memory formation are intact. We found that environmental enrichment may improve retention of memory and strength of learning in HX mice (Figure 6). Compared to non-enriched mice, HX / E mice were more successful as assessed by percent time in target quadrant and PP score during the Day 9 probe trial ($p < .001$); in fact, their performance was similar to NX mice, indicating that enrichment can offset the insult of hypoxia (Figure 6). The enhancement facilitated by enrichment may be accomplished by neurogenesis, which contributes to functional recovery (Fan et al., 2007). Since the hippocampus is critical in spatial tasks, it is possible that hippocampal neurogenesis was the mechanism in the improvement of behavioral task performance of HX / E mice (Figure 6). In future studies, immunohistochemical analysis should be conducted in the hippocampus. Small amounts of neurogenesis also occur in the cortex, and it is accelerated after an injury such as hypoxia (Fagel et al., 2006; Magavi et al., 2000). The addition of cells may have been sufficient to explain the significant increase in cortical volume of HX / E mice over HX / NE mice (Figure 3, Table 3).

Environmental Enrichment Has Positive Effects on Brain and Behavior

We have shown that chronic sublethal perinatal hypoxia is detrimental to the mouse brain. We have also presented a means to recuperate the developing brain and behavior: a stimulating environment. Therefore, the biochemical implications of the external environment can be drastic. Mice reared in complex environments have longer dendrites and more synapses per neuron, and enrichment results in altered distribution of metabolic resources to synapses and neurons through changes in vascular,

Table 3**Number of Cortical PV Neurons and Cortical Volume**

Hypoxic mice were exposed to chronic sublethal hypoxia from postnatal Day 3 (P3) to P11. Enriched mice were reared in environmentally enriched cages from P20 to P47. PV, parvalbumin.

	Normoxia, Non-Enriched	N =	Normoxia, Enriched	N =	Hypoxia, Non-Enriched	N =	Hypoxia, Enriched	N =
Total number of PV+ neurons	1,347,711	3	1,707,150	2	800,984	3	1,182,538	2
Cortical volume (μm^3)	5.07E+10	2	6.07E+10	2	3.63E+10	3	5.34E+10	2

mitochondrial, and glial support (Sirevaag & Greenough, 1987; Wallace et al., 1992). With a decrease of PV, synaptic activity is hindered, but the increased contact of astrocytes and synapses caused by enrichment can compensate for this effect and produce a functionally normal mouse brain (Galarreta & Hestrin, 2002; Jones & Greenough, 1996). Since the animal model used in the present research parallels the neurodevelopment of preterm VLBW individuals, the positive effects of enrichment are highly encouraging in consideration of human therapies. Aspects of the environmental enrichment of the lab setting can be adapted for preterm VLBW children in the home and classroom settings.

We have tested only a small number of animals but with more mice, conclusions may be solidified and more revelations may emerge. Future research is also necessary to determine if hypoxia and enrichment affects a particular cortical region, and if volume deficits are caused by shrinkage of cells, early cell death, or the development of fewer cells. We have discovered that the cortex is vulnerable to hypoxia but could not detect differences in the basal ganglia (Figure 3A, Table 3). Future studies could examine effects of hypoxia on other brain regions, such as the hippocampus, which is a site of neurogenesis critical to spatial memory, or specific regions of the cerebral cortex, such as the parietal cortex, which is critical for spatial memory.

Today, infants weighing less than 1000 g (2.2 lb) represent almost 1% of live births in the United States (Bassan et al., 2006; Guyer et al., 1999). Animal studies such as the present research demonstrate trends of lasting negative effects initiated by perinatal low oxygen rearing, and how such effects may contribute to the cognitive and behavioral disabilities of preterm VLBW children. However, we show that the deficits are not necessarily permanent – for the animals of the study or for the parallel human population. There are encouraging treatments that may reduce hypoxia-induced deficits; one that we propose here is a stimulating environment. We suggest that this research may be extended to therapeutic objectives for humans, such as preterm VLBW infants, who have endured hypoxemia. Environmental enrichment may be applied to human therapies in the form of educational toys, exciting teaching methods, colorful classrooms, social interaction provided by recess, and novel settings provided by field trips. Using the animal model of chronic sublethal perinatal hypoxia and environmental enrichment, research can provide valuable insights into neural, cognitive, and behavioral effects of hypoxemia. With further studies, we can work towards developing therapies to reduce hypoxemia-induced disabilities. ■

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