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Letter from the Editors

We are very pleased to be able to publish the second issue of Psi: the McGill Undergraduate Psychology Journal. Producing this journal has been an exciting experience for us, and has allowed us to continue breaking ground in the publishing process. This year, we tried to implement a more democratic article selection and editing procedure, encouraging input from the editors on all aspects of publication. In doing so, we hope to have created an enjoyable experience for all the editors and authors involved.

We are also proud to present to you a very multi-disciplinary journal. The range of subjects covered in this year's issue is exciting, as it demonstrates the varied interests and strengths of McGill's undergraduate psychology students and the wide variety of topics in psychology. We are pleased to offer you articles which draw from the fields of cognition, psycholinguistics, neuropsychology, social psychology, computational psychology, and many more. We hope that you delight in the diversity of articles, and continue to support the journal in the years to come.

Sincerely,



Erryl Jane Taggart, Editor in Chief



Lisa Zhang, Editor in Chief

On the Cover

Of the original ten inkblots used in the Rorschach test, the cover image is one of the only three done in colour. We felt that the diversity and vibrancy of colour in this image mirrored what we hoped to accomplish in this journal. This image is also a good representation of the field psychology as a whole, as there is only one popular interpretation of this card: human.

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Benefits and Risks of Strong Neighborhood Identification in Low-income Communities

Scott Neufeld

Introduction

Cities around the world contain neighborhoods that are characterized by a concentration of social problems and low socioeconomic status not shared with the rest of the city's inhabitants. These neighborhoods may be referred to as slums, ghettos, shantytowns, or simply the "bad part of town", and they are nearly always home to the city's poorest residents. Concentrated areas of low-income housing are the natural result of overurbanization and the rising cost of living (Easton, 2004). These forces invariably force the poor into the only areas of the city where they can afford to live, often in overcrowded, substandard housing.

Poor neighborhoods are frequently plagued with a vast array of health problems. Overcrowding leads to unsanitary conditions, easier transmission of disease, and increased emotional stress (Easton, 2004). High levels of stress among poor populations, particularly those experiencing additional difficulty from racial oppression and exclusion, have been found to have significant negative effects on health (Dressler, 1993). Baer, Singer, and Susser (1997) used the term "syndemic" to refer to the interaction of such health issues with the grave social conditions of the urban poor, resulting in a syndrome of poor health

outcomes for many residents of such neighborhoods. High rates of psychopathology have also consistently been found among individuals living in poverty (Costello, Compton, Keeler & Angold, 2003; Offord, Boyle, & Racine, 1989), and these correlations have been specifically linked to residence in a low-income neighborhood (Xue, Leventhal, Brooks-Gunn & Earls, 2005).

The relationship between poverty and poor health outcomes may be the result of social selection or social causation. The social selection hypothesis suggests that individuals with adverse health issues and psychopathological conditions are unable to find jobs or get support for their illness, causing a decline to lower socioeconomic status which necessitates their move to low-income neighborhoods. Alternatively, the social causation explanation suggests that it is the social context and environmental challenges of a life of poverty that contribute to the development and exacerbation of mental health problems. Research from the Boston Move To Opportunity study provides support for the causal effects of residence in a high-poverty neighborhood on poor mental health outcomes (Leventhal & Brooks-Gunn, 2000a). Significantly, parents who took the opportunity

to move their families to low-poverty neighborhoods reported less distress than their counterparts who remained in high-poverty neighborhoods, and boys in these families reported fewer symptoms related to anxiety and depression.

What are the factors mediating this relationship between neighborhood context and well-being? As Sampson (2003) has drawn attention to in his research on the neighborhood context of well-being, social context has a significant impact on health and it is important to understand the underlying mechanisms driving this relationship. For example, if residence in a neighborhood characterized by high levels of poverty, psychopathological disorders, high levels of substance abuse and violence was also associated with personal identification with the neighborhood, this may explain the relationship between neighborhood and health outcomes. In a review of several ethnographies of urban poor populations, Easton (2004) reported that indeed, low SES residents of an inner city neighborhood do seem to acquire an "urban poor" social identity related to their area of residence and status. Separated from the rest of society by social status and experience, characterized by problems not shared by their wealthier neighbors, and afflicted with increased rates of psychopathology and other negative health outcomes, members of low-income communities may naturally form a strong sense of social identity. This specific intergroup context may have unique implications for the collective well-being of such neighborhoods.

Social identity theory (Tajfel & Turner, 1979) proposes that all individuals are motivated to belong to social groups that are both psychologically distinct and positively evaluated. It is predicted that this will result in increased positive personal and collective esteem, which is linked to increased personal well-being (Taylor & Usborne, 2010). It would seem then that identifying strongly with one's neighborhood or community, if this represented a positive and distinct social identity, could be beneficial to personal well-being. Thus, strengthening neighborhood identification pres-

ents a possible avenue for increasing personal well-being. However, social identity theory also predicts that if an individual finds their social identity unsatisfactory they will either attempt to leave their group to join a more positive and psychologically distinct group (social mobility), or attempt to increase their group's positive evaluation and psychological distinctiveness (social change). In the case of individuals living in poverty, their socioeconomic status, health issues or other factors may contribute to an inability to engage in social mobility, thus leading them to redefine group characteristics (even potentially negative ones) as positive through a process known as "social creativity" (Jackson, Sullivan, Harnish, & Hodge, 1996). Indeed, Anderson's ethnography of youth violence in a low-income community (1998) suggests that certain highly dysfunctional behavioral norms in low-income neighborhoods can become internalized as an important and adaptive part of what it means to live and survive in a harsh inner-city environment. In the case of the "code of the street" described by Anderson, norms for violent altercations are incorporated into neighborhood identity with the functional outcome of decreasing "random" violence among residents; however the negative outcomes of increasing rates of violence generally and normalizing destructive and aggressive behavior likely outweigh the positive aspect of the code's functionality. In this sense, strong neighborhood identification in a low-income community may in fact be detrimental to an individual's health outcomes, exacerbating existing psychopathological symptoms and decreasing the possibility of an individual's escape from poverty.

This preliminary investigation of social identity at the neighborhood level leads to the question that is the focus of this paper: what are the benefits and risks of strong neighborhood identification in a low-income community? This question will be investigated by considering the meaning of neighborhood identification, assessing potential benefits and risks of strong neighborhood identification, and finally, based on this review, assessing some of the implications for community level interventions.

What Does it Mean to Identify With One's Neighborhood?

Much of the literature on neighborhoods has suffered from a diversity of definitions of "neighborhood" as a construct to be studied (Leventhal & Brooks-Gunn, 2000b). Census tracts have frequently been used in such studies to delineate the boundaries of a neighborhood, preferred because of the wide amount of existing data from past censuses. However, census tracts may be less than adequate as a neighborhood definition if we are interested in understanding the effects of social identification with one's neighborhood. As Farrell, Aubry, and Coulombe (2004) have noted in their research into neighborhood-level sense of community, the area contained within census tracts is often too large to be socially meaningful to residents. These census tracts often incorporate several distinct and socially heterogeneous neighborhoods into one area of description, and thus represent a plurality of potential social identities rather than a single coherent one. A feeling of group membership is mediated by the tension between a group's inclusiveness and uniqueness, and people tend to seek an optimal level of distinctiveness for their group (Brewer, 1991). This suggests that a strong sense of neighborhood identification will not exist across several distinct neighborhoods with diverse composition and problems, but is more likely to develop in smaller, geographically bounded and relatively socially homogeneous neighborhoods that are socially meaningful to residents. Even so, these smaller scale conceptions of neighborhood may still be too large for residents to socially identify with in a meaningful way, such that they are individually influenced by group norms and values shared collectively by the neighborhood. Farrell et al. (2004) note as a limitation to their study that even their careful selection of socially meaningful "neighborhoods" as defined by residents may not be the ideal approach to investigating a sense of community. They suggest instead that perhaps even smaller groups such as single apartment buildings, particular city blocks or interest groups form the most salient social groups in a neighborhood context. One explanation for this may be

the role of choice in group membership. Several studies have shown that groups whose members report a higher degree of choice in belonging to that group also report higher levels of psychological sense of community (Compas, 1981), and more in-group bias (Finchilescu, 1986), than individuals belonging to groups where they perceive less choice in their membership. In a research study using undergraduate students, Obst and White (2007) found that participants' social identification and psychological sense of community within their neighborhood was significantly lower than with two other social groups to which participants belonged, in which they had a higher degree of choice in their membership. The authors point out that neighborhood residence is only a choice to a certain extent; it may be limited by a desire to be close to friends and family, the presence of social support systems in geographically bounded areas, and the limited availability of affordable housing, particularly in the case of low-income individuals. However, this study only investigated the phenomenon in undergraduates, a group much more likely to relate to their peers at university than to their neighborhood. Long-term residents familiar with the community's history and collective experience may be more inclined to identify more strongly with their neighborhood. Nevertheless, smaller social groups where members exercise a high degree of choice in belonging may form important social identities for individuals located within their immediate communities. Therefore, in the study of social identity at the neighborhood level it is better to focus on smaller representations of neighborhoods, defined by boundaries that are meaningful to residents and where the influence of behaviors and norms of one's neighbors are salient.

Within these social groupings, do people in low-income communities form distinct social identities? In reference to research on poverty and cultural identity, Small, Harding, and Lamont (2010) use the term "boundary work" to describe the process members of low-income communities undergo, "constructing collective identity by differentiating oneself from others by drawing on

criteria such as common traits and experiences as well as a sense of shared belonging” (p. 18). Common experiences may include a shared history, for example of neighborhood oppression or economic downturn resulting in widespread poverty, which has been shown to help define a group’s cultural or collective identity (Hammack, 2008). In line with this research, Bougie, Osborne, de la Sablonniere, and Taylor (2010) found that the historical experience of a group’s collective relative deprivation was related to current feelings of collective esteem for both Anglophone Quebecois and Francophone Quebecois. If a group’s shared history involved periods of “collective relative deprivation”, a feeling that their group was disadvantaged in comparison to another advantaged group to which they would socially compare themselves, this appeared to help to “define or make real” (Bougie et al., 2010, p. 17) the group’s current collective identity which in turn resulted in positive associations with collective esteem. This is somewhat counterintuitive as much of the early social identity literature suggested that collective relative deprivation would be associated with negative collective esteem (Taylor & Moghaddam, 1994), but it appears to instead occasionally serve as a means by which collective identity may be clarified. The particular context of Francophones and Anglophones in this study may not precisely correspond with that of people living in low-income neighborhoods. However a shared history of governmental neglect, oppression based on ethnicity (some low-income neighborhoods are relatively ethnically homogenous), and economic hardship may effectively provide individuals living in a low-income neighborhood (especially those who have lived in poverty for a long time or whose families have experienced poverty for several generations) with a shared history including times of relative deprivation, and subsequent collective identity clarification along these dimensions. More support for this approach to collective identity based in reaction to outgroup oppression is found in the work of Branscombe, Schmitt, and Harvey (1999). They describe a “rejection-identification” model of identity based on their research, which found that minority group

members experienced direct negative effects of discrimination against their group, but indirect positive effects through increased identification with the minority group. However, such feelings of oppression and alienation amongst the poor and subsequent clarity of the boundary between rich and poor may also be a product of a nation’s political and cultural climate as Lamont (2000) has found that working class views of the poor may be more denigrating and alienating in individualistic, capitalist countries (e.g. the USA) than in socialist countries (e.g. France).

While clear collective identities may exist under certain circumstances in high poverty urban environments, we must be careful to distinguish between social identification with one’s neighborhood or smaller social groups within a neighborhood context and a generalized view of poverty as a “culture” (Small et al., 2010). In ethnographies by both Small (2004) and Harding (2007) their conclusion was that low-income communities are in fact frequently culturally heterogeneous in this respect, often consisting of various individuals responding to poverty in many different ways, rather than cohesively as members of a unitary cultural approach to life in poverty. These findings confirm earlier work in hierarchical linear modeling approaches to research on neighborhood effects reviewed by Leventhal and Brooks-Gunn (2000b) that found that the degree of variability of such effects tended to be greater within neighborhoods than across neighborhoods. This suggests that not all individuals within a low-income community necessarily identify with the neighborhood or are negatively affected by their residence there. An example is Anderson’s (1998) ethnographic account of the “decent” and “street” kids of inner-city Philadelphia, evidence of the fact that “similarly poor people living in the same high-poverty neighborhoods make substantially different decisions” (Small et al., 2010 p. 9) in many important areas of their lives. Certainly the potential for social identification and a feeling of group membership with neighborhood residence exists in low-income communities, but this is not always a present or

stable reality of neighborhood experience.

Benefits of Strong Neighborhood Identification in Low-Income Communities

There are certain attributes of a strong sense of community and neighborhood identification that may be beneficial for people living in low-income communities. One of the earliest, and most widely popularized, presentations of the adaptive function of low-income community identity was renowned anthropologist Oscar Lewis's description of the "culture of poverty" (1966a). In his ethnographic study of families living in poverty in Puerto Rico, and later Mexico, Lewis observed a cultural response to poverty that, "provides human beings with a design for living, with a ready-made set of solutions for human problems, and so serves a significant adaptive function" (Lewis, 1966b, p.19). Lewis observed that the behavior of families and individuals living in poverty was often predictable and exhibited patterns of how people adapt to difficult economic circumstances with "local, spontaneous attempts to meet needs not served" (1996b, p. 21). Lewis felt that while these cultural differences amongst the poor were observable and predictable, they rarely translated into a true sense of organized community or social identity, except in certain circumstances where barrios or slums were well defined within a city by clear barriers. Lewis admired the propensity to live in the moment and revel in sensual pleasures (Lewis, 1996b) that the temporal orientation of those with a "culture of poverty" engendered. Lewis saw this as a characteristic trait of the poor that the rich in their busy and overworked lifestyles could come to envy. However, the most defining feature of the culture of poverty for Lewis was its sense of alienation from the mainstream, which for the most part resulted in "feelings of despair and apathy" (1996b, p. 23) that often persisted from generation to generation. Poverty was not equivalent with the culture of poverty for Lewis; not everyone who experienced poverty would necessarily develop a "culture of poverty", and he firmly believed that such a negative culture did not exist among the

similarly poor in socialist countries such as Cuba. This finding may be echoed in more recent work by Lamont (2000) demonstrating a far less alienating view of the poor in socialist compared to capitalist political systems.

Lewis's work on the culture of poverty received much criticism in decades following. Many scholars (e.g. Roach & Gurrslin, 1967; Valentine, 1968; Gorski, 2008) accused him and other likeminded researchers of locating the problems of poverty too much within the victims themselves. The accusation was commonly made that Lewis was "blaming the victim" for their status and advocating for the complete obliteration of the "culture of poverty". In retrospect, such academic backlash towards the "culture of poverty" idea was probably less about Lewis's actual work (many of his detractors hadn't even read Lewis's major works; Harvey & Reed, 1996) than it was about the way American policy makers had misapprehended it as the theoretical basis for a largely unsuccessful approach to poverty policy. Specifically, the "culture of poverty" hypothesis was used in the United States as the impetus to avoid structural economic reforms in favor of focusing on ameliorating the broken "cultural value systems" (Bourgeois, 2001 p. 11905) of the poor through social work type interventions. As Harvey and Reed argued in their 1996 defense of Lewis's work, the ideological war that came out of discussions of a culture of poverty concluded with the establishment of the topic as a pariah in the academic world, effectively limiting the explanatory range of future work on poverty, and impeding any approaches that sought to focus interventions on the adaptive potential of the poor. It is only recently that researchers have begun to seriously reconsider the intersection of poverty and culture, as evidenced by the newly published special edition of the *Annals of the American Academy of Political and Social Science* dedicated entirely to this topic (edited by Small et al., 2010). In one of this volume's articles, Wilson (2010) provides an updated definition of "culture" that may more accurately describe a neighborhood separated by its poverty as, "the sharing of outlooks and modes of be-

havior among individuals who face similar place-based circumstances” (p. 202). This definition seems much better suited to describing the adaptive potential of cultural identity at the neighborhood level in economically poor neighborhoods.

If we are to consider the possibility of low-income community cultural identity, what are the specific benefits of such an identity? Taylor and Usborne (2010) have proposed a theory of cultural identity primacy, wherein a clear sense of collective identity clarifies personal identity, and a clear personal identity is requisite for positive self-esteem. As the authors explain, you cannot know if you are any good (personal self-esteem) unless you know who you are (personal identity), and this evaluation of personal worth is only possible in the context of a clear collective identity or normative framework against which to compare oneself. Taylor and Usborne also argue that an individual’s cultural identity is typically the most salient of collective identities, unique in its ability to provide individuals with a guiding normative framework that pertains to all aspects of an individual’s life, a shared history, and broadly defined goals (2010, p. 99). It would seem that this definition of cultural identity bears important similarities to both Lewis’s earlier conception of culture in the context of poverty and Wilson’s updated definition of the construct noted above. Related to the concept of shared history in collective identity, Small (2004) found that low-income residents of a public housing project in Boston were more likely to participate in their community when they viewed their neighborhood in terms of its history of political mobilization and collective action. This suggests that a clear sense of community culture and history will predict the amount an individual will contribute to improving their community. Taken with Usborne and Taylor’s (2010) finding from a variety of studies in different contexts that clear cultural identity is linked to clear personal identity and increased subjective well-being, this makes identification with a “culture of poverty,” or perhaps a more locally oriented neighborhood identity, particularly interesting as a potential avenue of increased well-

being for residents of low-income communities.

At the neighborhood level, the related concept of “psychological sense of community” (PSOC), developed in 1986 by McMillan and Chavis as a theoretical framework for conceptualizing community, has been a focal point for much research on neighborhood well-being in the field of community psychology. The key components of their construct are membership, influence, integration and fulfillment of needs, and shared emotional connections (McMillan & Chavis, 1986), all of which relate closely to constructs such as cultural and collective identity. Davidson and Cotter (1991) found that sense of community was positively and significantly related to subjective well being (SWB) in a telephone survey study of three separate random samples (each assessing three factors of SWB: happiness, worrying, and coping with personal problems). However Davidson and Cotter’s study only examined “sense of community” with city as the referent, so these findings do not necessarily generalize to the neighborhood level. More recent work on the construct has revealed interesting protective properties of increased psychological sense of community. For example, in a study of neighborhood ties along socially meaningful boundaries, Farrell et al. (2004) found that a strong psychological sense of community mediates the relationship between neighborhood stability and residents’ well-being. Similarly, researchers investigating both an urban and a rural area in Greece found a negative association between PSOC and negative mood, antisocial tendencies and aggressive behavior and a positive association between PSOC and social joining (Roussi, Rapti, & Kiosseglou, 2006), once again suggesting a possible benefit for low-income communities forming a strong sense of community with their neighborhood.

A construct bearing much conceptual overlap with psychological sense of community is “sense of community belonging”, and this has also frequently been linked with increased general health and mental health (e.g. Shields, 2008). In an investigation of what specific aspects of “social capi-

tal” the question “describe your level of sense of belonging to your local community,” a measure of “sense of community belonging” frequently used on public health surveys in Canada since 2000 (Shields, 2008), was really measuring, Carpiano and Hystad (2011) found that it most closely correlated with neighborhood social capital, such as the number of close friends and relatives an individual had in their immediate geographic vicinity, rather than general social capital. Carpiano and Hystad’s results also confirmed previous findings that sense of community belonging is significantly related to both self-reported general health and mental health, but only in urban settings and not for rural respondents.

The concept of “social capital” has received much attention in studies of neighborhood effects and is a necessary component of group membership and interaction. Defined by Bourdieu as “the aggregate of actual or potential resources linked to possession of a durable [social] network...” (1986, p. 51), which are available to members of a group in the absence of economic capital, this construct may have particular importance for understanding the potential benefits of identification and involvement within low-income communities. Features of social capital may include “networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit” (Putnam, 1995, p. 2-3), and “social support, social leverage, informal social control, and neighborhood organization participation” (Carpiano, 2007). In his investigation of neighborhood health benefits related to aspects of social capital from Bourdieu’s perspective, Carpiano (2007) found that social leverage was related to decreased daily smoking and informal social control was related to decreased levels of binge-drinking. Research by Stack (1974) investigated the benefits of one form of social capital particularly associated with urban poor neighborhoods: extended family networks. Stack demonstrated how these social networks and norms of social reciprocity in low-income African American populations are natural adaptations to the challenges of living in poverty, further

evidence suggesting that communities of urban poor have the potential to benefit from identification and involvement with their neighborhood.

Neighborhood identification and involvement may also have protective effects for certain types of psychopathology. One study, using census tract data from the Los Angeles Family and Neighborhood study, found that collective efficacy and linguistic isolation in neighborhoods was negatively associated with depression (Vega, Ang, Rodriguez & Finch, 2011). In this study, “linguistic isolation” referred to the relative ethnic and linguistic homogeneity of the neighborhood, which in this case were mainly comprised of Spanish-speaking individuals. Here, it would seem, a salient cultural identity reinforced by well-defined mono-linguistic social networks, and collective efficacy within this low-income community increased “conformity to community normative expectations and reduce[d] social deviance” (Vega et al., 2011, p. 122). As this study demonstrated, low-income neighborhoods (and neighborhoods generally) are frequently relatively ethnically homogeneous, providing an important interplay between neighborhood identification and cultural identification. In a recent study, Guerrerro et al. (2010) found that low cultural identification among Filipino youths in Hawai’i was linked with higher rates of delinquent behavior, with both parental absence and negative peer influence mediating the relationship. In another study by Guerrero et al. (2006), indirect measures of cultural identification (e.g. knowledge of family history, speaking a heritage language) were found to have some protective effect against substance abuse and academic underachievement. Similarly, Rieckmann, Wadsworth, and Dheyle (2004) found that increased cultural awareness and identity in Navajo youth was protective against depression, serving to decrease isolation, increase resiliency and generally contribute to increased mental well-being. From this review it would seem that there are many potential benefits for improved personal and collective well-being from increased cultural and social identification and neighborhood involvement, and perhaps uniquely

so for neighborhoods with shared ethnic identity or common experiences of economic hardship.

Risks of Strong Neighborhood Identification in Low-Income Communities

Having described potential benefits of identification and participation in low-income communities this paper will now describe possible risks associated with strong neighborhood identification. Returning to the neighborhood literature, residence in areas of concentrated poverty has consistently been shown to correlate with negative outcomes such as social alienation, unemployment, high drop-out rates among youth, educational underachievement, crime, delinquency, violence, and dysfunctional family organization (Small & Newman, 2001). It seems reasonable to suggest that residence in a neighborhood characterized by such negative features would constitute membership in a negatively evaluated social identity: "the neighborhood I live in". Tajfel (1981) predicted that individuals would leave a group that provided a negatively evaluated social identity, but this is not possible in the case of ascribed categories such as gender, ethnicity, or in this case, socioeconomic status and residence in a poor neighborhood. Many people who reside in poor neighborhoods cannot afford to live anywhere else or improve their SES (particularly if their poverty is partially caused by mental illness), limiting their social mobility. In situations where social mobility is thus impeded, social identity theory (Tajfel & Turner, 1979) predicts that individuals may seek to improve their positive evaluation through a process of social creativity by either 1) comparing their in-group to the out-group on some new dimension, 2) psychologically re-evaluating negative group traits as positive group traits, or 3) changing the out-group with which the in-group is compared to provide more favorable social comparisons. Thus it is possible that a social identity characterized by dysfunctional behavior and poor health outcomes may become internalized and positively evaluated to meet the adaptive need of a positively distinct social identity. An example of this kind of iden-

tification with dysfunctional behavior may come from Aboriginal communities in Canada, where a recent survey found that 71% of Aboriginal adults felt alcohol was a problem in their reserve community (EKOS Research Associates, 2006). In the "cultural identity vacuum" experienced by many Aboriginals in the wake of colonialism (Taylor, 1997), widespread problems with alcohol abuse may have been internalized as a salient aspect of modern Aboriginal identity, such that in some cases, alcoholism may be seen as a "valid expression of Indianness" (Beauvais & LaBoeuff, 1985, p. 158).

Concrete examples of maladaptive identification with low-income neighborhoods are described in a few recent studies. Wilson (2010) points to findings from several studies of the subculture of inner-city black youth that described risky sexual behavior, drug use, idleness, and participation in a "hip-hop" lifestyle as examples of cultural traits adopted from poor neighborhoods that may hinder social mobility, perpetuating such youths' disadvantaged position. Sampson, Sharkey, and Raudenbush (2008) also showed that extended residence in a severely disadvantaged neighborhood produced noticeable long term effects on verbal ability in a large sample of African American youth and adolescents. Another example comes from Ogbu's work on the description of an "oppositional culture" in poor black students that regarded academic achievement as "acting white" and thus undesirable (Ogbu, 1978). However, Small et al. (2010) report that Ogbu's arguments have not been substantiated by empirical studies of nationally representative data (e.g. Cook & Ludwig, 1998), and many have questioned his culturally based theories of why many black students remain disadvantaged. In response to these studies, Ogbu wrote a defense of his previous work (2004), arguing that his critics had reduced his theory to a mere "oppositional culture theory" rather than what he really presented as a cultural-ecological theory firmly grounded in a historical understanding of blacks in America. Ogbu felt that the history of oppression and forced intergroup conflict during the time of American slavery of Africans was a crucial context

largely being ignored by modern education scholars who only focused on the “transactions between the students and their school” (p. 2) to understand poor academic outcomes of black students.

Related to social and cultural identity is the aforementioned construct of psychological sense of community. Initially, a consistent finding was that increased PSOC was linked with positive outcomes like increased personal well-being until Brodsky (1996), for the first time, found that PSOC could have a negative dimension as well. When resilient African American single mothers in high-risk communities reported a distinct lack of PSOC, this enabled them to cope with their high-risk environment because they did not identify with their dysfunctional community. Hence, positive PSOC may serve a maladaptive function in certain contexts where the community in question is characterized by negative norms and values. In a similar study, Caughy, Campo, and Muntaner (2003) found that increased self-reports by African American parents on a measure of PSOC that specifically targeted how well the respondent knew their neighbors provided different outcomes in different contexts. PSOC specifically related to how well parents knew their neighbors was correlated with decreased amounts of internalizing behavior for preschool-aged children of respondents living in low-poverty neighborhoods, but with increased amounts of internalizing behavior for children of respondents living in high-poverty neighborhoods.

These risk aspects of PSOC likely stem from the negative influences of deviant peers within a low-income neighborhood context. In their review of the literature on neighborhood effects, Leventhal and Brooks-Gunn (2000b) point out that while studies have found that high levels of peer support moderate neighborhood effects related to antisocial behavior, substance abuse and school achievement, these effects were only beneficial in low-risk neighborhoods where peers were not engaging in these behaviors to begin with. In high-risk neighborhoods, increased levels of peer support were related to neighborhood effects of the outcomes

above that were detrimental to individuals. It would seem that increased peer involvement in communities with high levels of dysfunctional behavior leads to social learning, adherence to dysfunctional behavioral norms and identification with negative aspects of neighborhood life. Similarly, while Carpiano (2007) was cited above for his finding that social leverage and informal social control were negatively related to daily smoking and binge drinking respectively, the same study also reported that neighborhood social support was positively related with both smoking and binge drinking, as these behaviors are often social in nature.

While Putnam (2000) and many others have argued vociferously for the importance and benefit of social capital in society, there have been many critics of such views for their emphasis on only the positive aspects of social capital, without due attention to the downside of social capital (e.g. Portes, 1998; Browning et al., 2004; Carpiano, 2007). Even James Coleman, one of the earliest sociologists to use the term “social capital”, was aware that while features of social capital could facilitate certain actions, in some contexts they “may be useless or even harmful” (1988, p. 98). One of the most prolific critics of Putnam’s work, Alejandro Portes, has clearly explained how social capital, as a finite resource within a community, must take away benefits from some in proportion to the benefits it confers to others (1998). He lists several specific drawbacks of increased social capital, such as out-group exclusion resulting from tight in-group bonds, the restriction of individual freedom in close-knit groups, and downward leveling pressure whereby group members are discouraged from engaging in social mobility, potentially even if the group in question is negatively evaluated. One final example of the downside of social capital is found in the area of community violence research. Communities high in collective efficacy, a form of social organization that has been found to regulate neighborhood crime by some researchers (Sampson, Raudenbush, & Earls, 1997), present a paradox of sorts in the benefits of social capital. Browning, Feinberg, and Dietz (2004) have found that

the same social networks bolstering the neighborhood's sense of community also provide the social capital that often enables criminals to offend, yet another example of the downside of social capital.

While it would seem that the potential risks of a high degree of social identification or involvement with one's low-income neighborhood are many, it has also been suggested in this paper that there is at least the potential for these group processes to be psychologically beneficial. The relative benefits and risks of such communities appear to be determined by the nature of the neighborhood identity that has developed. A short article on a positive form of local identity termed "civic identity" (a sense of geographic community and willingness to contribute to that community's health and functioning) amongst youth living in high poverty urban neighborhoods suggests that the positive potential of neighborhood identification is not realized in these communities (Atkins & Hart, 2003). The authors argue that decreased social capital in low-income communities (e.g. low levels of civic participation, higher social distrust in urban areas, racial segregation and isolation, and fewer civically engaged adult role models) prevents youth from developing strong civic identities. They then present analyses from the National Household Educational Survey (1999) that show that indeed, only 30% of high-poverty, urban-neighborhood youth participated in community service (compared with 44% of suburban youth). Such youth were .30 standard deviations below the mean on measures of civic knowledge, and also scored lower on measures of political tolerance than youth from low poverty neighborhoods. These statistics do not tell a hopeful story for youth in low-income urban communities.

Implications for Interventions and Conclusion

The study of neighborhood identification and social involvement has revealed a potentially important avenue for consideration in the development of community-level poverty interventions, but also a challenge. The issue is to attempt to find

a way to enact interventions that focus on building a positively defined sense of local community which can benefit personal self-esteem and provide a pro-social guiding framework for goals, behaviors, and beliefs, while avoiding the creation of a neighborhood identity that is dysfunctional and ultimately harmful to individual residents.

Lewis (1966b) observed that the populations he studied seemed to have a limited view of their group or neighborhood's shared history, which may present one possible approach to identity clarification interventions. For example, Hammack (2008) has advocated for the use of "cultural narrative" techniques to study cultural identity, wherein an individual is asked to write out the history or shared story of their group. A group's shared story has been found to be an important part of collective identity (Ashmore, Deaux & McLaughlin-Volpe, 2004) and a cultural narrative approach may also provide a way of helping a group clarify their collective identity. This approach to community intervention is currently being investigated by Esther Usborne at the Université de Montreal. In another possible avenue of intervention, Hill (1996) has suggested that many people's most salient communities are not their geographic ones, but smaller, personal interest groups. These may have a more positively evaluated social identity and could provide an "escape identity" with which individuals could identify, instead of a dysfunctional neighborhood. Finally, collective action in response to threats to neighborhood life (e.g. gentrification, discriminatory social policy) has been found to help clarify community identity (Dalby & Mackenzie, 1997) suggesting grassroots neighborhood organization against oppressive systemic forces may help improve neighborhood collective esteem.

Effective interventions such as these will only be developed from reliable, empirical research into the association of group identification and poverty. As such, more research is needed to accurately describe the particular intergroup context of the urban poor and the possible application of the work of Taylor and Usborne (2010) on the im-

portance of cultural identity clarity for personal wellbeing. More cross-discipline conversation between researchers investigating issues of poverty may prove fruitful in contributing to the growing body of knowledge on the topic and help to standardize definitions such as “cultural identity” in the particular context of study. Indeed, Small et al (2010) recommend that such an interdisciplinary approach to the study of culture and poverty is necessary for the advancement of the field and, in particular, for movement away from the mistakes of past research. Above all, it will be important to appropriately balance our understanding of the role of both the cultural neighborhood and structural societal factors in the maintenance of systems of poverty in urban environments (Wilson, 2010).

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Top-down Feature Search Strategy Resists Attentional Capture by Emotionally Salient Stimuli

Danielle Marcovitz

Abstract

Visual search is the process by which we locate objects of interest in our environment. However, there is some debate as to the mechanisms at play. Bacon and Egeth (1994) found that color singleton distractors did not interfere with a search task when participants were conducting the search in a “feature search” mode. Theeuwes (2004) replicated this experiment but with a larger display size, and found that color singleton distractors did, in fact, interfere. The current study seeks to resolve these results by incorporating highly salient, emotional distractor stimuli into the design. The results show that, in accord with Bacon and Egeth (1994), aversive emotional distractors, non-aversive emotional distractors, and color singleton distractors did not cause a delay in reaction time. These findings can be explained in terms of several different and unexpected effects.

Introduction

Top-down selection is the volitional, goal-directed shift of attention that occurs when we concentrate on a task. Bottom-up selection occurs when an object in our environment draws our attention automatically and without our conscious intent, as a function of the salience of the object’s inherent properties (Buschman & Miller, 2007). Both serve a practical purpose. Top-down selection allows us to focus and exert the goal-directed effort needed to accomplish short- and long-term undertakings. Top-down selection is necessary for more complex cognitive functions. On the other hand, bottom-up selection serves a more primitive function. It is thought to direct our attention to stimuli in the environment that hold adaptive value. The orienting response refers to the heightening in attention that occurs automatically in re-

sponse to either novel or “signal” stimuli, such as food, mating partners, or, perhaps most critically, danger (Carretié Hinojosa, Martín-Loeches, Mercado & Tapia, 2004).

While the world of today seems far removed from a world where survival is uncertain and dependent on the orienting response, natural selection has ensured that even in contemporary times, each of us is equipped to respond optimally to biologically critical stimuli. Findings that emotional stimuli capture attention have been replicated in many studies through attentional blink paradigms (Arnell Killman & Fijavz, 2007), event-related potentials (ERP) (Carretié et al., 2004), eye tracking (Nummenmaa, Hyönä & Calvo, 2006) and disability studies (Vuilleumier

& Schwartz, 2001). Vuilleumier and Schwartz (2001) found that patients with unilateral neglect were consistently better at detecting aversive or threatening stimuli than neutral stimuli in their left visual field. This is particularly intriguing because it highlights how deeply ingrained the orienting response is to danger. In fact, ERP results demonstrate that aversive stimuli are signaled in the brain by a specific and separate pattern of activity from other biologically relevant stimuli (Carretié et al., 2004).

Findings supporting mechanisms like the orienting response correspond with a “salience perspective” of attentional selection, which holds that processing in the early stages of visual perception is dominated by bottom-up factors such as salience. At the other end of the spectrum is the “contingent capture account”, in which attention is strictly a top-down, volitional process. Bacon and Egeth (1994) posited two different search strategies available to us during a visual search task. Our visual and attentional systems enter singleton detection mode when our task is to locate one unique object, or singleton, among a background of many other like figures. This search mode hinges on the uniqueness of the target, and readies our system to respond to any “unlike” stimulus. Bacon and Egeth (1994) further stated that stimuli will only capture our attention in a bottom-up manner when we are in singleton detection mode. On the other hand, we enter a feature search mode when we are searching for a target stimulus amongst many unique singletons. In this mode, observers target their attention exclusively at specific features pertinent to the target, so that other irrelevant singletons do not distract from the search. Bacon and Egeth (1994) illustrated the principle of search modes by adapting an original experiment by Theeuwes (1992) on attention capture. In Theeuwes’ (1992) experiment, circle stimuli and a diamond shaped target were positioned around a fixation point. Each figure had a small line segment inside of it. The participants’ task was to locate the diamond target and indicate the orientation of the line

segment within it. Theeuwes found that reaction times in reporting the orientation of the line were delayed when a distractor stimulus in the form of a colored circle was added to the array. Bacon and Egeth (1994) posited that the uniformity of the other stimuli in the display allowed participants to engage in a singleton detection mode of search, whereby other unique singleton distractors, such as a colored circle, are able to draw attention away from the target singleton. In order to induce a feature search mode, Bacon and Egeth (1994) adapted Theeuwes’ (1992) experiment by adding a triangle and square singleton into the circle display. Under these conditions, reaction time in locating the diamond target was not affected by the colored distractors. Bacon and Egeth (1994) explained, “...The goal-directed selection of a specific known featural singleton identity may override stimulus-drive capture by salient singletons.”

In response to these findings, Theeuwes (2004) repeated Bacon and Egeth’s (1994) design with a larger display size of twenty items, and found that a colored circle distractor singleton did, in fact, decrease slow reaction time. He interpreted this finding as evidence against the notion of differential search modes and instead attributed it to simple bottom-up salience effects.

The current study seeks to resolve the findings of Bacon and Egeth (1994) and Theeuwes (2004). It will do so by incorporating emotionally salient images into Theeuwes’ (2004) twenty-item experimental design. Because emotional images have been highlighted by past research as especially salient, and because mechanisms for emotional attention capture are rooted in biological function, emotional stimuli represent the ultimate test of Bacon and Egeth’s (1994) theory of differential search modes. In particular, the current study discriminated between the attention-capturing effects of aversive and non-aversive emotional stimuli. It was hypothesized that reaction time for locating a target singleton will be slower when an aversive emotionally salient distractor is present in the search display than when a non-invasive

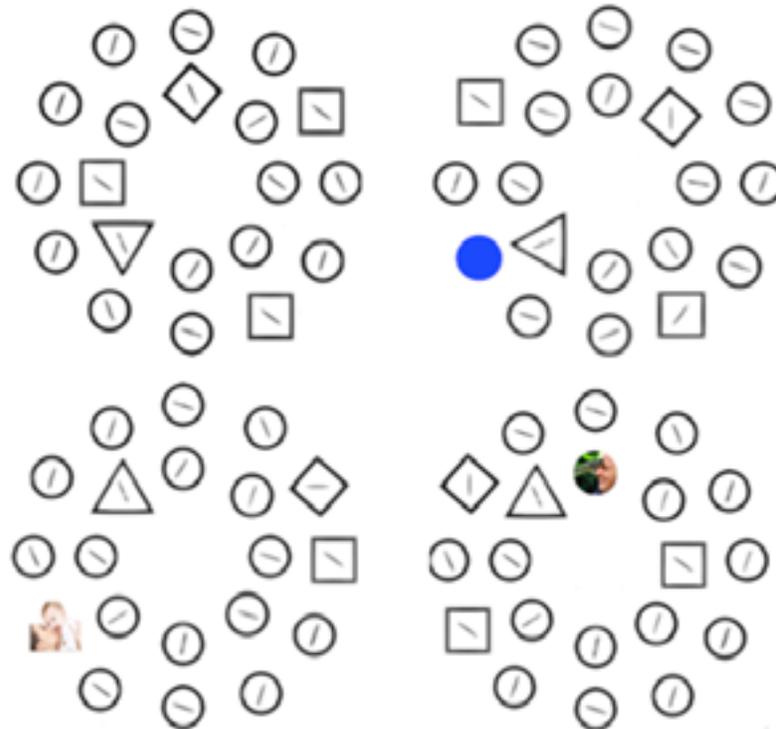


Figure 1. Examples of the stimuli displays. The top left panel presents the condition in which there was no distractor singleton present (adapted from Theeuwes, 2004). The top right panel presents the condition in which a color distractor singleton was present. The bottom left panel presents the condition in which there was a non-aversive emotional distractor singleton present. The bottom right panel presents the condition in which there was an aversive emotional distractor singleton present.

emotional distractor is present. Secondly, we hypothesized that reaction time will be slower in both emotional distractor conditions than in the colored circle distractor condition. Finally, in tandem with the findings of Theeuwes (2004), we hypothesized that reaction time will be slower in colored circle conditions than in control conditions containing no distractors.

Methods

Subjects and Design

Our sample was composed of 10 subjects, including three males and seven female student volunteers from the University of New South Wales ranging in age between 18 and 25 years. Twenty display elements were equally spaced around a fixation point in the center of a screen. The display consisted of outline circles, one square, one triangle, and one diamond target. All figures contained line segments at various orientations. There were 160 trials in total: 40 trials contained no distractor

stimulus and served as a control, 40 trials contained a colored circle stimulus in either pink, red, blue, purple, black, orange or green, 40 trials contained a neutral emotional complex image, and 40 trials contained an aversive emotional complex image. In a separate rating task, displays included the neutral and aversive complex images used in the previous task. There was one image per display, and all images were scaled to a constant size.

Procedure

At the start of the experiment, subjects were instructed to search for the diamond among all the other shapes, and indicate the orientation of the line segment within it. Participants were instructed to press either “z” to indicate that the line segment was of a horizontal orientation, or “/” if it was of a vertical orientation. The 120 trials were presented at random. Each trial was preceded by a masking stimulus and the presentation of a fixation cross for 550 ms. The participants were re-

selection instructions upon every trial. In the separate rating task, participants rated the valence of neutral and aversive complex images on a scale of onetoten, where onerepresented extremely unpleasant images and ten represented extremely pleasant).

Results

We carried out an independent samples t-test on the reaction time data. The comparison between reaction times in aversive and non-aversive emotional conditions yielded non-significant results ($F(1, 9) = 6.984, p > 0.05$). The comparison between emotional and colored circle conditions yielded non-significant results ($F(1, 9) = 3.267, p > 0.05$). The comparison between all experimental conditions (aversive emotional, non-aversive emotional, and colored circles) and the control condition yielded non-significant results ($F(1, 9) = 7.769, p > 0.05$). Therefore, the hypotheses that subjects' reaction times for locating a target singleton would be slower in (1) the aversive emotional condition than in the non-aversive emotional condition, (2) both the emotional distractor conditions than in the colored circle condition, and (3) the colored circle condition than in the control condition were all rejected. Raw data scores indicate that while the results of the statistical analyses were non-significant, the mean reaction times for the four conditions were consistent with the first hypothesis. The mean reaction time for the aversive emotional group ($M = 1791.93, SD = 385.25$) was higher than that for the non-aversive emotional group ($M = 1693.07, SD = 425.88$). Notably, the mean reaction time for the colored circle condition ($M = 1738.67, SD = 375.64$) was higher than that for the non-threatening emotional group, and, contrary to the third hypothesis, the mean of the control group ($M = 1969.08, SD = 410.69$) was the highest of all.

Discussion

The results are in accordance with those predicted by Bacon and Egeth's (1994) notion of dual search modes. The display was designed in order to induce a feature detection mode in which irrelevant singletons do not interfere with the search task. This might also serve to explain why the control

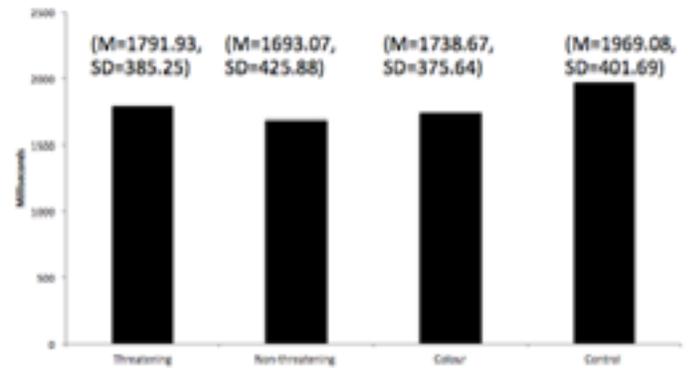


Figure 2. Means and standard deviations of all four conditions.

condition had the longest reaction time. If an observer's attention is fixated only on features relevant to the target—in this case, a simple diamond outline—then complex or colored images might be automatically dismissed as distractors and ignored altogether. These results correspond with the finding of Theeuwes (2004) in that search time increased with display size. If complex and colored images are automatically dismissed from our attentional resources, then displays containing a distractor singleton effectively contain one fewer potential target and display sizes become one unit smaller. This may have consequences for processing speed.

On the other hand, these unexpected results might also be otherwise explained by the orienting response. The orienting response refers to the increase in attention that occurs in response to either biologically relevant or novel stimuli (Carretié et al., 2004). The fact that the orienting response occurs in response to any novel or unexpected stimulus in addition to "signal" stimuli might explain why reaction times in the colored circle distractor conditions were similar to those in emotional distractor conditions. Furthermore, it might also explain the trend of faster reaction times for all distractor conditions compared to the reaction times for the control condition. It may be reasoned that if distractor stimuli trigger a spike in attention, this heightened attention might generalize to the task as a whole. Thus, the presence of a distractor singleton may actually cause an acceleration of processing, which is contrary to the original hypothesis.

The lack of statistically significant findings may be attributable to a number of limitations of our study. Firstly, the images used as emotional distractors in the display conditions were selected on the basis of their estimated hedonic valence. For control purposes, each participant rated their subjective perception of the valence of the images. In their experiment on attentional blink and emotional stimuli, Arnell et al. (2007) found that "...target accuracy was predicted by participants' arousal ratings to the critical distractor words and by their memory for them, but not by their valence ratings." This finding suggests that inappropriate emotional distractors may have been selected for inclusion in this study. It would be interesting to see if significant results could be obtained from images selected on the basis of their arousal properties.

Furthermore, the task used in our experiment was designed such that images were appraised and the target selected based on their perceptual characteristics (i.e. "search for the diamond"). Huang et al. (2008) found that emotional distractors did not affect attentional blink when the task was structured such that only perceptual processing of stimuli was required. Future experiments might adapt the design of the current study so that semantic rather than perceptual processing of the stimuli is required. Huang et al. (2008) also suggested that precedent studies (Eimer, Holmes, & McGlone, 2003; Erthal et al., 2005; Pessoa, McKenna, Gutierrez & Ungerleider, 2002) failed to find greater interference using emotional stimuli because these stimuli were task-irrelevant and often positioned away from the target, making them easier to ignore. This limitation might be avoided in future studies by placing the distractor closer to the target within the display.

Finally, the lack of significant results in the current experiment may be due to the small sample size. Results of previous experiments have shown that the attentional capturing effects of emotionally salient stimuli are often discriminable by mere milliseconds (Arnell et al., 2007; Theeuwes, 1992;

Theeuwes, 2004). It thus follows that it would be very difficult to obtain statistically significant and consistent differences in the millisecond range from a small sample size such as ten. It should be mentioned, however, that Theeuwes (2004) did find statistically significant results in his own experiment with a sample size of eight.

The findings of the present study support the results of Bacon and Egeth (1994) and their dual search mode account of attention processing and capture. However, the results leave room for explanation by a number of unconfirmed phenomena and mechanisms. The current research is significant in its extension of knowledge in the domain of vision and attentional processes, and in its ability to stimulate future research in the field.

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Variation on Death Rate and Its Effect on the Dominance of Ethnocentrism in Agent-based Simulation

David Chak

Abstract

Ethnocentrism is a nearly universal syndrome of discriminatory attitudes and behaviours. It has been suggested that ethnocentrism may be a result of natural selection (Hammond & Axelrod 2006). Hammond and Axelrod (2006) and Shultz et al. (2008; 2009) provided substantial evidence in support of the theory. An agent-based simulation by Hammond & Axelrod used a fixed death rate throughout the simulation. This paper aims to enhance the original simulation by including variations in the death rate. Death rate was changed using six methods. The results show that a humanitarian strategy rather than an ethnocentric strategy could evolve to be a dominant strategy given linear and quadratic change in death rate. This suggests that the idea of ethnocentrism being an evolutionary-stable strategy may be incorrect as there is a possibility for a humanitarian strategy to be an evolutionary-stable strategy as well.

Introduction

Ethnocentrism refers to a syndrome of discriminatory attitudes where one sees his or her own group (the in-group) as being superior to other groups (the out-group). Ethnocentrism increases cooperative relations between in-group members and decreases cooperative relations between individuals belonging to different groups (LeVine & Campbell, 1972). In this case, a cooperative relation is defined as a cooperative strategy between the two interacting agents. Ethnocentrism results from the existence of group boundaries defined by observable characteristics indicating common descent, territory, or even by the most trivial and arbitrary group definitions, such as the ability to estimate dots projected on a screen (Sumner, 1906; Tajfel, 1970; Tajfel et al, 1971). For the purpose of this paper, ethnocentric behaviour will be defined

as behavior demonstrating in-group favouritism, a definition consistent with that used by the original simulation (Hammond & Axelrod, 2006).

Evidence suggests that even when there are few cognitive processes involved and with abstract social input, there is still a predisposition toward in-groups bias (Hammond & Axelrod, 2006). Hammond & Axelrod (2006) explored ethnocentrism using an evolution simulation model where by an evolutionary environment was simulated. This evolution simulation entails an agent-based model where a large number of agents operate and interact in an environment. . These agents' behaviours are governed by rules triggered by their local condition rather than global information. To put in laymen's term, this refers to an evolutionary model

where there are various characters (agents) in the simulation, and these characters interact with other characters with the very basic rules they were programmed to follow. A local condition, is defined as the condition of itself and its surrounding neighbour, for instance, what would the character do when it sees a stranger in its immediate vicinity? When it sees a member of its type, how should it interact? Should it cooperate or should it not cooperate? Whereas, global information refers to variables that governs the entire simulation, for example, the current cycle the simulation is in. In Hammond and Axelrod's (2006) evolution simulation model, ethnocentric behaviour evolved to dominate all other possible strategies and became the strategy adopted by 75% of the population. An important limitation of the original study was that the model assumed the death rate (the probability of an agent dying before reaching the next generation of simulation) to be a constant value throughout the simulation. However, a constant death rate used in the simulation is an over-simplification and does not reflect evolutionary reality. This may have resulted in a bias in the selection of certain behaviours throughout evolution, for instance, there may have been a large number of a certain strategy surviving in the early stage.

Human life expectancy has increased throughout human history. This indicates that the death rate assumed in the simulation should be a changing value that take into account of the longer life expectancies – in other words, the probability of each agent dying should be decreasing by each generation, rather than staying as a constant. In order to avoid a bias in behavior selection, the probability of an agent dying before reaching the next generation should decrease as evolution progresses. This assumption of a longer human life expectancy is based on two things.

First, longevity (or having longer lifespan) may be a naturally selected trait (Galor & Moav, 2005). Individuals who are able to adapt to a changing environment tend to live longer; therefore,

they have a genetic potential for increased life expectancy. These individuals will be more likely to pass on their genetics due to increased opportunity to produce more offspring. Their offspring would also inherit the genetic potential for increased life expectancy, and consequently, they would also be more likely to pass on their genetic material. Natural selection's evolutionary pressure favours individuals who are able to increase their lifespan and produce more offspring. In the long run, this would result in an increase in human life expectancy throughout evolution (Galor & Moav, 2005).

Secondly, the ability of humans to adapt to the environment has improved over the course of evolution, resulting in an increased life expectancy. For example, by discovering fire, humans were able to keep warm in cold weather, therefore reducing death caused by cold weather. The discovery of modern medicine provided humans with the ability to cure diseases and sickness. Alternatively, certain aspects of human evolution may have resulted in increasing mortality rates, such as the increase in diseases due to habitation in more populated areas (Tarwater & Martin, 2001). However, given the fact the empirical evidence shows an increased life expectancy in human evolution (Caspari & Lee, 2004), it is assumed that this net effect of human adaptation has resulted in an increased life expectancy.

The previous evidence provided indicates that, death rate is not a constant value in human evolution history and instead, it is a changing value. This paper will replicate the work of Hammond and Axelrod (2006) while taking into account a reduction in death rate at each generation in the simulation.

Methods

The simulation began by generating a torus of size 50 X 50 cells. We set the parameters as: cost of helping = 0.01, benefit of receiving help = 0.03, base reproductive rates = 0.12, mutation rate = 0.05, immigration rate = 1, run length = 500

There were 4 tags in the simulation and 4 strategies in the simulation. The groups were defined by the tags which act as identification of in-group and out-group. The strategies defined were selfishness (always defect), traitor (defect in-group but cooperative to out-group), ethnocentrism (cooperative to in-group but defect out-group) and humanitarian (always cooperative). At each round, the agents would decide if they want to donate to their neighbours based on their game strategy, their own tag, and the neighbours' tag. The summary of the strategies are stated in the following table:

	In-group	Out-group
Selfishness	Defect	Defect
Traitor	Defect	Cooperate
Ethnocentric	Cooperate	Defect
Humanitarian	Cooperate	Cooperate

The simulation was repeated for 500 rounds. For each round, there were four stages:

- 1) Interaction – An agent was created with random strategy and random tag and was placed randomly in an empty site on the lattice
- 2) Interaction – The agents interacted with their neighbours based on their defined tag, their neighbour's tag, and their game strategies. The outcome of the interaction would affect the agents' reproductive rates. If an agent decided to give help, its reproductive rate was reduced by 0.01 and the receiving neighbours' reproductive rate would increase by 0.03.
- 3) Reproduction – Each agent was given a chance to reproduce equal to its reproductive rate. If an agent was able to reproduce and there was at least one empty space adjacent to the agent, an offspring of the agent, with identical characteristics would then be placed adjacent to the agent. The offspring's characteristics were identical to its parents but each trait had the potential to change with the probability equal to mutation rate (0.05)

- 4) Death – Each agent had a chance of dying (and being removed from the lattice) equal to the death rate

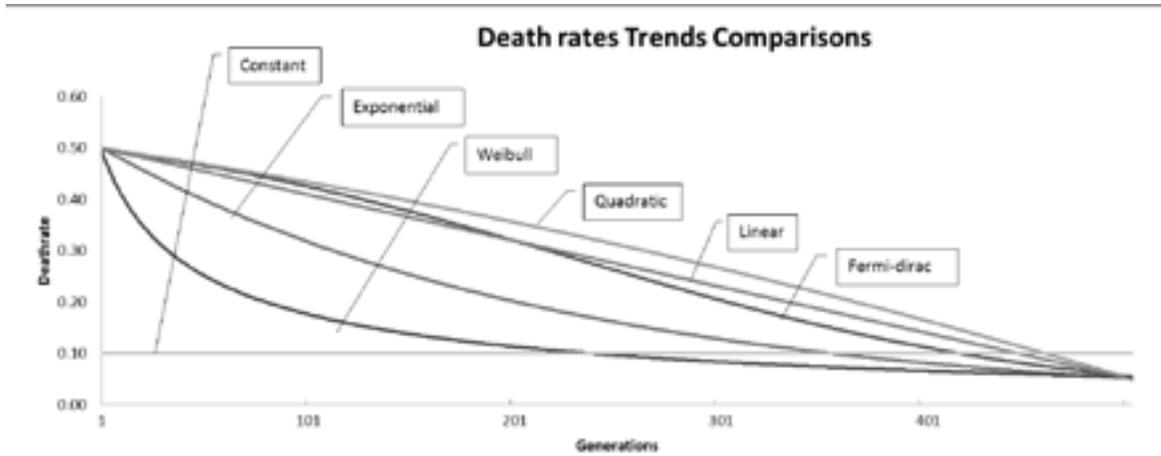
In this simulation, the death rate began at 0.5 and gradually decreased to 0.05. This value was arbitrarily chosen. Any range of decreasing values should yield the similar results as the key variable was the way death rate decreases.

There are at least five different methods of varying the death rate, including linear, quadratic, exponential, exponential using the Weibull distribution¹, and the Fermi-Dirac distribution equation. The formulas that were used are listed below with x being the current generation number:

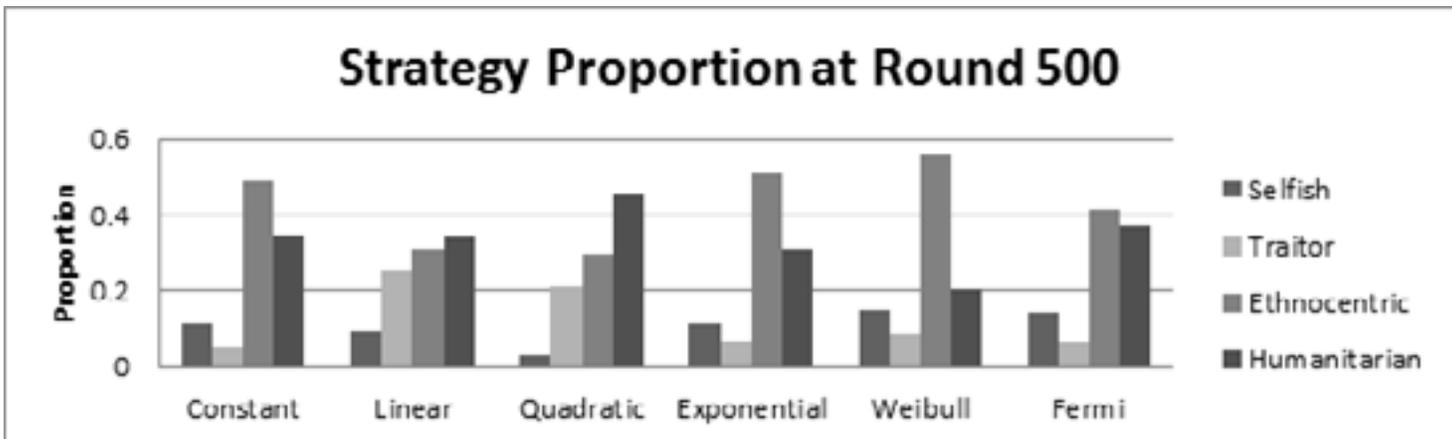
- 1) Linear: $-0.0009 * x + 0.5$
- 2) Quadratic:
 $(-4 * 10^{-7}) x^2 - (6 * 10^{-4}) x + 0.5$
- 3) Exponential:
 $e^{(-0.7x)}$
- 4) Exponential with Weibull distribution:
 $\frac{0.5}{4} \left(\frac{x}{4}\right)^{(-0.5)} e^{-(x/4)^{0.5}}$
- 5) Fermi-Dirac distribution:

$$\frac{0.57}{(230 + e^{\frac{x-230}{17*50^{0.5}}})}$$

The following graph (graph 1) showed the death rate trend for each of the different formulas.



Graph 1. Comparison of various death trends

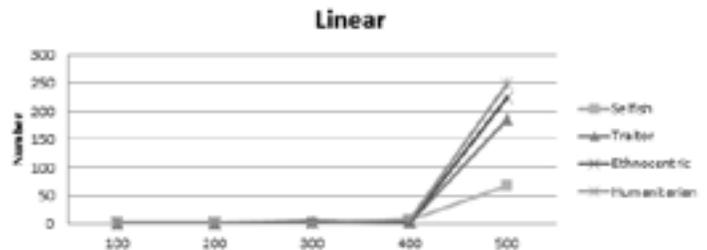


Graph 2. Proportion for different strategy for each death trend

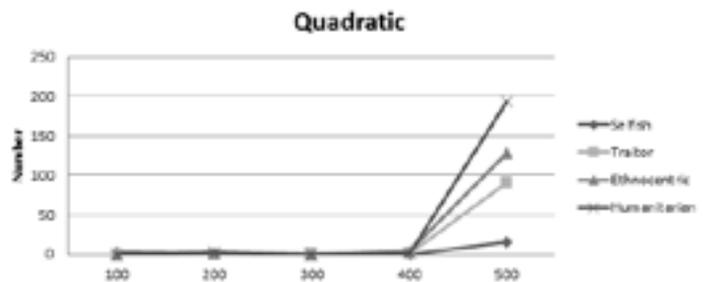
Results

In all the ways of varying the death rate, with the exception of linear and quadratic trend, an ethnocentric strategy became a dominant strategy by generation 500. However, for the linear and quadratic methods the humanitarian strategy became dominant.

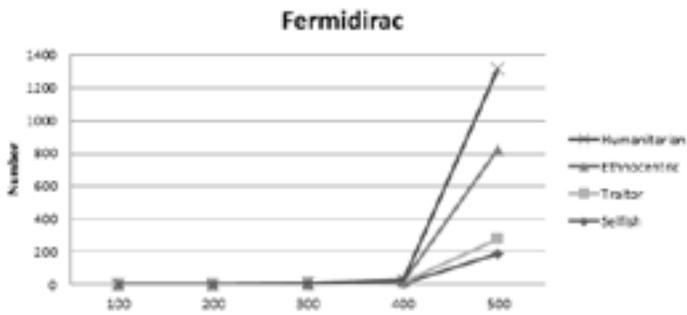
Linear, quadratic, and Fermi-Dirac method displayed a sudden spurt of growth for all strategies at approximately generation 400 (refer graph 3, 4 and 5). For an exponential death rate, the evolution of each strategy was exponential (graph 6). For the Weibull exponential death rate, the evolution rates for each strategy were quadratic. (graph 7)



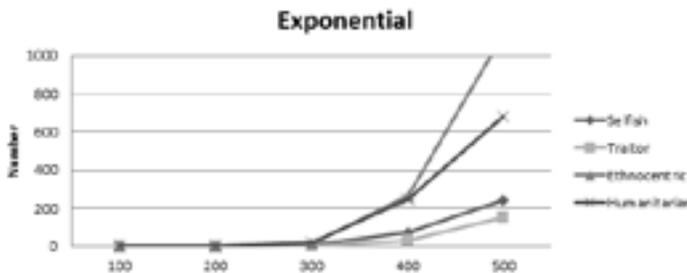
Graph 3. Growth of strategies for linear method



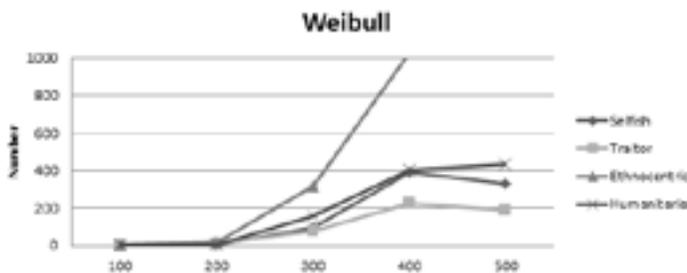
Graph 4. Growth of strategies for quadratic method



Graph 5. Growth of strategies for Fermi-Dirac method



Graph 6. Growth of strategies for exponential



Graph 7. Growth of strategies for Weibull method

Discussion

The fact that ethnocentrism did not evolve to become a dominant strategy in all cases may indicate that ethnocentrism is not as robust as previously thought. According to Shultz et al. (2008), a humanitarian strategy has the capacity to compete successfully and dominate over other strategies during earlier generations. The simulation provides evidence for this proposal, indicating that with a specific variation in death rate, the humanitarian strategy is capable of becoming a dominant strategy. Unfortunately, it is not currently known how the death rate has varied over evolution.

While ethnocentric behaviour has been proven robust in countless experiments (Hammond & Axelrod, 2006; Levine 1972; Tajfel 1970, Tajfel et al.,

1971), it is important to be cautious when purporting that ethnocentrism is a universal behaviour. A humanitarian strategy may also be interpreted as a universal altruistic behaviour, as this strategy would cooperate regardless of group identity. An individual with universal altruistic behaviour would help others regardless of who he/she is helping, this is analogous to the humanitarian strategy as humanitarian strategist would cooperate regardless of others' tag.

Altruism has been extensively studied in behavioural economics, and empirical evidence has been found for the universality of altruistic behaviour (Andreoni, Harbaugh, & Vesterlund, 2007). For example, after ruling out various factors such as social distance and self-esteem need, evidence indicates that individuals are willing to fairly split money they have been given with others (Forsythe et al., 1994; Hoffman 1996). On average, participants were willing to share 25% of their endowments with other participants (Andreoni et al., 2007). This demonstrates the existence of altruistic behaviour, even without in-group favouritism.

However, the evidence presented here is not conclusive enough to argue that altruism naturally selected. Further research is required to explore this area. Potential future research may involve a more detailed analysis of each stage of the simulation as was done by Shultz et al. (2008, 2009), running larger scale simulations (> 500 generations), and repletion and averaging of results.

An alternative explanation other than that altruistic is an evolutionary-stable strategy, would be that ethnocentrism lacks humanitarian neighbours to exploit, and therefore, it could not evolve to be a dominant strategy. Shultz et al. (2009) argued that ethnocentric strategies dominate humanitarian strategies, by exploiting humanitarian cooperation along the frontier border where the two groups come in contact with. This exploitation from agents using an ethnocentric strategy would select against a humanitarian strategy. However, due to varying death rates and the death rate being high in early stages, ethnocentric agents may be less likely to encounter humanitarian agents, and

therefore, they would be less likely to exploit the humanitarian agents. With fewer ethnocentric agents to exploit them, humanitarian agents are less likely to be selected against.

There are two limitations to this simulation. First, the range for death rate was done by arbitrary selection. Further exploration is needed to explore the effect of the range on the results. Second, there was a lack of proper statistical analysis. A formal statistical analysis is needed to properly examine the results across different death rate variations.

In conclusion, the current study provides a different perspective on the Hammond and Axelrod (2006) study. It is important that researchers be careful in selecting the variables that they use. As shown in this case, the use of a varying death rate may lead to different results. This study shows that under the right condition, a humanitarian strategy could evolve to be an evolutionary dominant strategy.

Disclaimer: David Chak was not involved in the publication of this article, which was selected for publication anonymously by a conference of the editorial board.

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The Time Lag Between First-Person Pronoun Acquisition and Second-Person Pronoun Acquisition

Wing Yiu Stephanie Wong

Abstract

The acquisition of personal pronouns is different from the acquisition of most words. Personal pronouns shift referent as the speaker in a conversation changes; therefore a child cannot learn the proper usage of personal pronouns through imitation. Shultz (1994) used a cascade-correlation model to simulate the learning of pronouns through direct speech and overheard speech. The overheard speech simulation is modeled after a child who is listening to a conversation between his/her parents. However, studies suggest that the second-person pronoun is harder to acquire than the first-person pronoun because the referent can change even as the speaker remains the same (Clark, 1978). To model this observed phenomenon, the simulation described in this report extends Shultz's original model by adding another referent for you in the non-addressee condition to see how this manipulation may affect pronoun acquisition.

Introduction

Personal pronouns are classified as deixis, words that depend on context, because they shift referent as the speaker in a conversation changes. Consequently, personal pronouns cannot be learned by imitation because when a caregiver talks to his or her child, me refers to the caregiver and you refers to the child (Ricard, 1999). When children do attempt to learn by imitation, they show temporary pronominal reversal errors (i.e. using you instead of I) (Dale & Crain-Thoreson, 1993). In order to acquire personal pronouns, children must learn that these lexical items do not have stable referents, but that whom they refer to is relative to the speaker's point of view. Most children acquire the correct usage of personal pronouns by age three, but some still show persistence in reversal errors for a few months

longer (Clark, 1978). There are different theories that account for the gradual mastery of personal pronouns, and among them is Oshima-Takane's (1988) hypothesis that children may learn the semantic rules for personal pronouns by attending to overheard speech and making inferences. In overheard speech, children can observe that the second-person pronoun can refer to someone other than themselves. Conversely, in speech directly addressed to children, they can observe that the second-person pronoun refers to themselves. Oshima-Takane (1988) found that children profit more in terms of speed of pronoun acquisition from overheard speech than from speech addressed to them. Due to the fact that second-born children are likely to have more opportunities to hear pronouns used

Condition	Speaker	Addressee	Referent	Pronoun
Addressee	Father	Child	Father	Me
	Father	Child	Child	You
	Mother	Child	Mother	Me
	Mother	Child	Child	You
	Sibling	Child	Sibling	Me
	Sibling	Child	Child	You
Non-addressee	Father	Mother	Father	Me
	Father	Mother	Mother	You
	Father	Sibling	Sibling	You
	Mother	Father	Mother	Me
	Mother	Father	Father	You
	Mother	Sibling	Sibling	You

Table 1. Phase 1 training patterns

in overheard speech, such as in conversations between their parent and older sibling, they succeed in pronoun production earlier than first-borns.

Shultz, Buckingham, and Oshima-Takane (1994) used cascade-correlation to model the learning of pronouns and the effects of overheard speech and direct speech on pronoun acquisition. Cascade-correlation begins with a minimal network, consisting of only an input and a later output. It then adds new hidden units that receive trainable input from the input units and any existing hidden units. When a new hidden unit is added, its input-side weights are frozen and the unit contributes to producing outputs (Fahlman & Lebiere, 1990). Learning speed can be modeled with cascade-correlation because the model learns only one level at a time and declares victory when all of the outputs are within the score-threshold of their targets. In Shultz et al.'s 1994 model, two experiments were run: experiment 1 compared pronoun acquisition from direct speech and from overheard speech, and in experiment 2, the ratio of direct speech and overheard speech were varied and the consequential results were analyzed. Similar to the results found in Oshima-Takane's (1988) study, Shultz et al. (1994) found that children exposed to overheard speech produced less reversal errors, if any at all, than children exposed only to direct speech. Furthermore, experiment 2 also showed that the more overheard speech a child is exposed to, the faster pronouns would be acquired.

Speaker	Addressee	Referent	Pronoun
Child	Father	Child	Me
Child	Father	Father	You
Child	Mother	Child	Me
Child	Mother	Mother	You
Child	Sibling	Child	Me
Child	Sibling	Sibling	You

Table 2. Phase 2 training patterns

Clark claims that the first-person pronoun shifts referent with every change of speaker, but the second-person pronoun shifts even more frequently because it can be used by the same speaker to refer to different addressees. This hypothesis mirrors real-life experiences; in cases where a child has older siblings, a parent would be addressing the other parent and any siblings with the pronoun you. This study extended Shultz's 1994 model to test the impact of having more than one addressee in overheard speech on personal pronoun acquisition.

Method

This simulation, running on AllegroCL, elaborated on experiment 1 of Shultz et al.'s 1994 model, which is divided into several components. The experiment contained two conditions: "addressee", where the child was only exposed to direct speech, and "non-addressee", where the child was only exposed to overheard speech. The training patterns were divided into phase 1 and 2. Phase 1 involved the child listening to speech, which was modeled through each network, and learning the initial six training patterns (Table 1) associated with the specific condition. Phase 2 modeled the child's successful production of pronouns, where six more training patterns (Table 2) were added. The phase 1 training patterns in the extended model consisted of six utterances for each condition shown in Table 1, contrasting with the four utterances seen in the original model, which resulted from adding "Sibling" as a potential additional

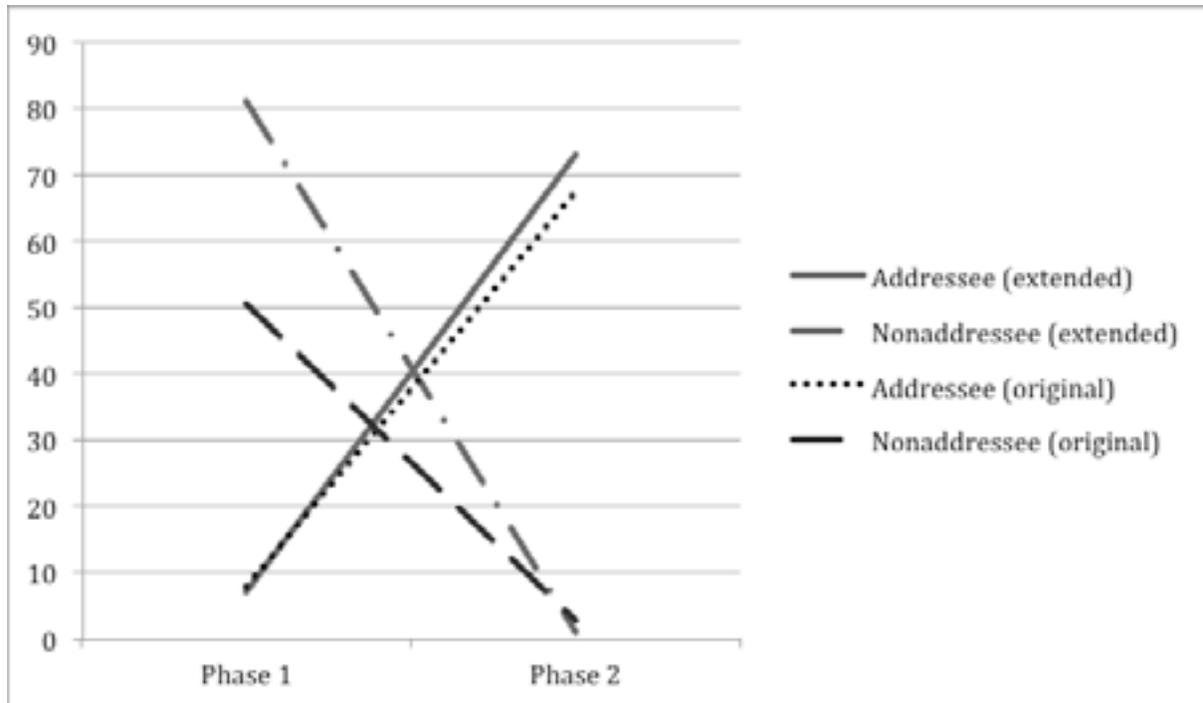


Figure 1. Mean epochs for each phase

speaker/addressee. For example, when the father uses the pronoun you in the overheard speech condition, he could be referring to the mother in some cases, and the sibling in others.

Results

In the addressee condition, the mean number of epochs, which is the time unit used in simulations, to learn in phase 1 was 6.9, and the mean number of epochs spent in phase 2 was 73.05. In the non-addressee condition, the mean epochs spent learning in phase 1 was 81.05, and the mean was 0.9 for phase 2. As with Shultz's model, a hidden unit was recruited in phase 1 of the non-addressee condition and in phase 2 of the addressee condition. Figure 1 demonstrates the contrast in the findings in this model and Shultz's model. Schultz found that the mean epochs for phase 1 in the non-addressee condition were significantly lower than that of the extended model presented here. However, the mean epochs for phase 2 were significantly higher in Schultz's model than in the extended model. The mean error for the addressee condition was 0.66 and the mean error for the non-addressee condition was 0.363.

Discussion

There are few differences seen in the addressee condition of the original model and the extended model. This result is to be expected because the child is still experiencing the same two-way conversation where the child will always be referred to as you by the person speaking to him/her, be it the father, mother or sibling. The extended simulation shows that, as previously predicted, adding an additional addressee in the non-addressee condition leads to an increase in learning time. This finding reflects Clark's (1978) hypothesis that when the pronoun you refers to different addressees by the same speaker, it increases the difficulty of second-person pronoun acquisition and hence, more time is required for a child to acquire it in phase 1. However, the results of the extended model show that having an additional addressee in the non-addressee condition leads to a smaller number of epochs in phase 2 and a lower error rate than that of the non-addressee condition in the original model. This finding suggests that adding an additional addressee provides the child with more information about the shifting referent of the second-person pronoun, and although it takes longer to acquire in phase 1, it allows the child

to generalize correctly and minimize production errors.

It would be interesting to further expand experiment 2 of Shultz's model by varying the number of addressees in the non-addressee model. The findings from this simulation suggests that increasing the number of addressees increases the number of epochs in phase 1 and also decreases the error rate and the number of epochs in phase 2. Thus, one can hypothesize that to minimize reversal errors, a child should be exposed to a ratio of high non-addressee speech and low addressee speech, and in addition, the non-addressee speech should contain more than one addressee per speaker.

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Desegregated Schooling, Cooperative Learning, and Other Anti-Bias Programs Affect the Racial Attitudes and Cross-Race Friendships of Students

Johan Jaquet

Introduction

We live in a globalized world, where societies are composed of multi-ethnic populations. In this context, many inter-group tensions, prejudices and discriminations do arise. Yet, from a developmental point of view, inter-group attitudes and relations are built from an early age (Bar-Tal, 1996). In addition, Miller and Sears (1986) found support for the persistence hypothesis, which states that childhood socialization influences attitudes in adulthood, though early adult socialization has an impact as well. School is a crucially important context, since it is generally there that children encounter their first “out-group” peers – that is to say, people from other ethnic or social groups. As a consequence, and especially in the USA, effort has been put into the development of strategies targeting the improvement of inter-ethnic relations between children. It is thus of paramount importance to determine whether, when and to what extent these different strategies work. For instance, simply putting different groups together has been theorized to reduce prejudice – the so-called contact hypothesis – but this strategy is efficient only in certain conditions, such as when there is an equal status between groups (Allport, 1954; Binder et al., 2009).

Effects on Interracial Attitudes and Prejudice

The impact of anti-bias strategies has often been evaluated by examining intergroup attitudes using various indicators. For instance, some researchers used judgements of in-group and out-group targets based on pictures. In a cross-sectional design assessing the effect of bilingual education, Wright and Tropp (2005) compared three types of classrooms in which 5-to-9-year-old pupils were educated: ethnically mixed Latino-Caucasian classrooms with bilingual instruction (English-Spanish); mixed English-only instruction; predominantly Caucasian classrooms with English-only instruction. The outcomes were measured by asking Caucasian children to select pictures of unknown children of the same age and of various ethnicities, according to several criteria. First, when asked to select children “that are good at lots of things” (a measure of inter-group evaluation), participants tended to choose Caucasian (71%) targets more often than Latino (63%) targets. However, the bias for selecting Caucasian targets was smaller in bilingual and mixed English-only classrooms, supporting the contact hypothesis. Second, when the children were asked to choose targets as friends (a measure of friendship preference),

they did so more often for Caucasian than Latino targets (46% vs 30%), but the bias was reduced in the bilingual setting. Third, the in-group versus out-group bias for perceived similarity (38% vs 17%) was reduced in bilingual classrooms, but not in mixed English-only classrooms. These two last findings do not support the contact hypothesis alone, and suggest that valuing the language of the “out-group”, or at least making it more familiar for English-speaking Caucasian children, may also have a positive impact. Moreover, it is important to note that all these bias reductions were due to more positive perception of Latino targets, and not to more negative perception of Caucasian targets.

A recent longitudinal study pointed out that the causality between inter-group contact and inter-group attitudes may be bidirectional (Binder et al., 2009). During the study, 1655 secondary school students from both ethnic minorities (immigrants) and majorities (natives) in three European countries (Belgium, England and Germany) were surveyed on two occasions six months apart. The study measured prejudice with two scales: one assessing negative emotions toward the out-group, the other evaluating the extent to which a participant wished to maintain social distance. More precisely, social distance represents the intention of not having social interactions of varying intimacy with members of the targeted outgroup (Binder et al., 2009). Inter-group contact was not manipulated but rather measured by the quantity (how many) and quality (distance, equality, cooperation) of out-group friends. The authors found that higher quantity of contact at Time 1 predicted lower prejudice (both in terms of emotions and social distance) at Time 2. Furthermore, higher prejudice at Time 1 predicted lower quantity of contact at Time 2. Similar findings were found for quality of contact. However, though all effects were significant as a result of the large sample size, the regression coefficients were small (ranging from -.05 to -.21).

The two aforementioned studies evaluated the effect of ongoing situations, rather than actual

interventions targeting the reduction of bias. The study conducted by “Fluent Public Opinion” (2008) is different in that perspective. This study evaluated the effect of watching *Sesame Street*, at least twice a week during a six week period, on attitudes and educational outcomes. The sample was composed of 264 Serbian and 272 Albanian children, 5-6 years old, residing in Kosovo. *Sesame Street* is an educational TV program aimed at increasing academic skills of children, as well as their acceptance of other cultures and traditions (Fluent Public Opinion, 2008). The program had a positive effect on mutual respect, a composite measure of judgments based on photographs of out-group children (recognition of similarities with an African-American child, receptiveness to a Roma child, receptiveness to a Serbian/Albanian child, etc.). Indeed, the proportion of children scoring at least 80 (out of 100) on this measure increased significantly in the intervention group (from 30% to 49%) but not in the control group (27% to 30%). However, the effect is less clear when considering the sub-measure of receptiveness to a Serbian (for Albanians) or Albanian (for Serbians) child, which was measured through a series of scenario-based questions. Though the authors reported a higher receptiveness in the post-test for the intervention group (standardized mean=53.3) than for the control group (50.8), the pre-test measure showed roughly the same difference (51.1 and 49.0 respectively). The authors should have reported an interaction effect to support the effectiveness of the intervention, that is to say, an improvement in the intervention group (here, $d=53.3-51.1=2.20$) significantly greater than in the control group (here, $d=50.8-49.0=1.80$).

Many other educational interventions targeting improvement in interracial attitudes have been implemented and evaluated, throughout the entire curriculum from preschool to university. For example, Hogan and Mallott (2005) examined the effect of taking a course about race and gender issues on modern racism of a predominantly Caucasian sample of psychology and sociology students. Modern racism is a racial prejudice

construct, with three components: denial of the existence of discrimination against African-American; resentment regarding social gains of minorities; antagonism towards equality policies. It was measured by the McConahay's Modern Racism Scale (McConahay, 1986; Hogan & Mallott, 2005). The authors used seven five-point scale items, resulting in a range of possible total scores from 5 to 35. As a whole, students who took the course had a lower post-test score in modern racism (14.17) than in pre-test (15.83). Conversely, students who had taken the course one or two years earlier, as well as students who had never taken it, showed an increased score through the semester (from 14.55 to 15.44 and from 14.68 to 16.46, respectively).

More specifically the post-test showed no difference between groups on the sub-scale measuring resentment toward progresses in racial equity. In contrast, antagonism toward governmental egalitarian policies was lower in the group that took the course recently than in the other groups. However, a decline in scores for the denial sub-scale (one 5-point item measuring the extent to which one denies that racial discrimination is still a problem) was maintained in older followers of the course (post-test mean = 1.71, compared to 1.62 for recent followers and 2.17 for never-followers).

Another intervention, targeting attitudes toward minorities in a predominantly Latino (74.8%) sample of grade 4 to 6 pupils in a New York City public school, consisted of having participants read and discuss four dramatic plays relating difficulties encountered by various minorities (Gimmestad & De Chiara, 1982). As a whole, the intervention group showed a greater improvement (.27) than the control group (a similar school, .06) on the 8-point Bogardus Social Distance Scale, which measures willingness for contact with specific ethnic groups (African American, Jewish, Puerto Rican and Chinese). However, though results were significant, even the largest effect (gain of social "closeness" of .49 toward African Americans) was small if one considers the 8-point scale.

Finally, the effects of a classical cooperative learning strategy (involving interracial cooperation in small teams) and the so-called jigsaw classroom on inter-group attitudes have been tested and compared in grade 4-6 pupils in Australia (Walker & Crogan, 1998). The jigsaw classroom is a cooperative learning strategy where students are interdependent; each of the members of the groups holds unique information needed to perform the task. Participants were Asians and European-Australians (Aboriginals were not represented in each condition). They were asked to rate two pictures of unknown members (one girl, one boy) of every three groups. This was a measure of social distance. The authors demonstrated positive outcomes for the jigsaw classroom on ratings of European-Australians and Asians. However, the intervention had a negative impact on ratings of Aboriginals, whereas the classical cooperative learning intervention had a negative impact on all three ratings. Similar findings were obtained on a 7-adjective scale measuring interracial prejudice. It can be inferred from the scales of social distance and interracial prejudice (4-point scales) that effect sizes were moderate to large. The authors reported significant differences from .95 to 1.86 points, but they did not mention standardized effect sizes (Walker & Crogan, 1998).

The conclusions of the six aforementioned studies evaluating interracial attitudes and prejudice are mixed: programs usually produce differences in the expected direction, but these effects are quite modest in general. Moreover, the effects are convincing for some outcomes but not others (e.g. the 2008 study on the *Sesame Street* program) and changes are not always maintained (Hogan & Mallott, 2005). As a whole, the findings moderately support the contact hypothesis and suggest that the quality of contact matters, for instance through friendship (Binder et al., 2009), by explicitly valuing characteristics of the out-groups (e.g. Wright & Tropp, 2005) and by favoring within-group interdependence (Walker & Crogan, 1998).

Effects on Cross-Race Friendships

Another method for assessing the impact of anti-bias strategies on improving relations between different ethnic groups is to examine cross-racial friendships that occur in children. Though we present separately the effects of strategies on interracial attitudes or prejudice on one hand, and on cross-race friendships on the other hand, note that these two variables are related (Binder et al., 2009). Many different strategies and programs were developed and implemented in the USA during the seventies for increasing intergroup friendships. Among them, different versions of the Teams-Games-Tournament (TGT), an between-teams competitive but within-teams cooperative intervention, have been evaluated by the number and percentage of cross-racial friendships (De Vries, Edwards, & Slavin, 1978). Seventh to twelfth graders who participated had to nominate peers who were their friends. As compared to traditional teaching, TGT was found to increase the number of cross-racial “friends in school” in three studies (out of four; χ^2 ranging from 8.5 to 16.1), but not significantly ($p > .05$) the proportion of cross-racial friendships among all friendships. De Vries and colleagues noted that this effect was due to a positive effect on all friendships, both with same-race and cross-race students. Similar measures of cross-racial friendships have been used by Walker and Crogan (1998) in their evaluation of the jigsaw classroom and the classical (without interdependence) cooperative program. Only the former method had significant positive outcomes on ratings of willingness to play and to work with out-group peers.

A third study evaluated the effect of a “Structured Cooperative Learning” (SCL) method on the popularity of immigrant and non-immigrant children in the Netherlands (Oortwijn, Boekaerts, Vedder, & Fortuin, 2008). In this study, 10-12 year-old pupils were put in small working groups of comparable academic skills and age and engaged in 11 lessons. The outcome – perceived popularity

– was a proxy of friendship rather than a direct measure of friendship. Perceived popularity was rated for each child by fellow team members at the beginning and end of the intervention (no control group). Popularity was increased by SCL exposure, but only in ethnically heterogeneous groups, as predicted by the contact hypothesis. Moreover, popularity scores increased significantly for non-immigrant targets (from 20.48 to 23.65, out of 40), whereas immigrants did not benefit from a significant gain in popularity (from 18.56 to 19.75).

In contrast, another study found that both Caucasian and African-American secondary school students had a higher number of other-race friends – measured on a 7-point scale from “almost all my friends” to “almost none of my friends” – when the organizational structure of the school was team-based ($M_s = 4.15$ and 3.53 for Caucasian and African-American respondents, respectively) rather than traditional (3.87 and 3.32) (Damico, Bell-Nathaniel, & Green, 1981). The team-based organization of the school (two schools in the sample) consisted of interactive teaching in multi-grade classes with mixed academic ability, in which students were randomly assigned to learning teams. The traditional structure (3 schools) segregated students by grade and academic ability, the latter criterion resulting in classes that were more ethnically homogeneous than the team-based classes.

Thus, it was not surprising that the team-structured schools resulted in higher numbers of interracial friendships, since the opportunity of contact was higher. This hypothesis has also been supported by a study by Hallinan and Smith (1985), which was conducted in eighteen classes of 4th to 7th graders in California. They found that the higher the proportion of African-Americans in classes (ranging from 17 to 89%), the higher the proportion of cross-race choices made by Caucasian pupils when asked about their “best friends”, and the lower the proportion of such cross-race choices by African-Americans. Moreover, though the effect was less clear, they found a negative correlation between class size and interracial friendliness for

Caucasians and African-Americans.

As a whole, and similar to the findings of the preceding section, the aforementioned studies suggest that no straightforward conclusion can be drawn regarding the consistency of the impact of contact and cooperative strategies on interracial friendship. However, the observed effects are all in the same positive direction, and thus suggest that ethnically mixed classes and cooperative learning methods tend to have a positive impact. Note that this is especially true when both cooperative learning and including different ethnicities in the same class are used together (Oortwijn et al., 2008).

Ethnicity Status (Majority vs. Minority) As a Moderator

Some of the studies presented in the previous sections showed different effects on students, depending on their ethnicity. This section is devoted to examining these differences in terms of minority or majority status, in order to detect a potential pattern. First, the positive effect of watching *Sesame Street* occurred only for Serbian children (a minority in Kosovo) and not for Albanians (the majority) (Fluent Public Opinion, 2008). Indeed, while the former showed a substantial gain in general “mutual respect” and receptiveness to an Albanian target ($d=0.42$ and 0.42), the latter did not show any gain ($d=.03$ and $-.05$). Similarly, the Structured Cooperative Learning method evaluated by Oortwijn and colleagues (2008) had a positive effect on the popularity of non-immigrants, but not on the popularity of immigrants. Together, these two findings suggest that minority groups (Serbians and immigrants, respectively) change more positively in terms of their attitude toward majority groups (Albanians and non-immigrants) when exposed to the programs (*Sesame Street* and SCL). Therefore, in turn, this greater change benefits the majority group members.

On the contrary, however, other studies suggest

that the effect of anti-bias strategies have more impact on the attitudes of members of majority groups. For example, Binder et al., 2009 found that quantity and quality of contact (number and quality of out-group friends) negatively predicted willingness for social distance and negative emotions towards the out-group, but only for the majority group (regression coefficients ranged from $-.05$ to $-.14$). Damico and colleagues (1981) reported similar results, as African-Americans are a minority in this US sample, even though they were the majority in some classes. In this study, after reporting how many friends of the other ethnic group they had, students had to rate their friends on a 10-item semantic differential task (energetic/lazy, pleasant/unpleasant, etc.). Caucasian students that scored at least 2 on the cross-race friendship scale (“some of my friends [are Black]”) evaluated their African-American friends less consistently with racial prejudice than those scoring 1 (“almost none of my friends [are Black]”), but the reciprocal effect for African-Americans’ ratings of Caucasian friends did not occur.

However, in the same study, both Caucasian and African-American students had a higher number of other-race friends in team-organized (rather than traditionally organized) classrooms. Similarly, Hallinan & Smith (1985) suggested that minorities may stick together and avoid close contact with the majority because they feel threatened, but did not find support for this hypothesis. Indeed, the proportion of African-Americans in the class did not influence the proportion of same-race friendship choices of Caucasians and African-Americans students.

In sum, the moderating effects of belonging to a majority group versus a minority group on interracial attitudes and friendship are very mixed. Three patterns are represented in the aforementioned studies; the positive impact of interventions is sometimes stronger for the majority group, sometimes stronger for the minority, and sometimes even. Therefore, more

research is needed to determine whether other factors, such as the relation between majority and minority, could qualify the effect of group status on sensitivity to anti-bias interventions.

Effects of Different Types of Intervention

Three different types of strategies emerge from the present review. Note that some of the studies use a combination of them, which can make it difficult to conclude which features contributed to what effects. The first strategy can be called “simple” intergroup contact, which stemmed from school desegregation in the USA. In this framework, Hallinan and Smith (1985) found that the more African-American students in a class, the more Caucasian students had African-American friends. Conversely, the lower the proportion of African-American students, the more African-Americans had Caucasian friends. These results are consistent with the positive effect of a team-based (vs. traditional) organizational structure of schools on the number of cross-race friendships, since the team-based structure was associated with ethnically heterogeneous composition (Damico et al., 1981). Furthermore, as suggested by Binder and colleagues (2009), intergroup friendships can foster reduction of prejudice of European natives toward minority groups, in terms of social distance and negative emotions. Moreover, though evaluations of Latino targets by Caucasian children seem to be positively influenced by being in an ethnically mixed class, this intergroup contact was not sufficient for fostering friendship willingness and for increasing perceived similarity toward these targets (Wright & Tropp, 2005). Indeed, this study suggests that giving both groups an equal status – here, by teaching in both languages – favours the positive effect of intergroup contact (Allport, 1954; Wright & Tropp, 2005).

A second strategy which has been widely used is cooperative learning. Research has shown positive effects for team-based class structure on interracial friendship (Damico et al., 1981) and of Structured

Cooperative Learning on the popularity of non-immigrants (Oortwijn et al., 2008). However, Walker and Crogan (1998) have pointed out that incautiously putting students from different groups together may increase inter-group tensions and worsen negative attitudes. Among the components of their jigsaw technique, these authors highlighted the importance of interdependence between members of a team, which consists of providing each member with necessary information that others do not possess. The authors showed that it was only in an interdependence condition that interracial liking of peers increased and prejudice decreased. However, these positive effects in intergroup relations between European-Australians and Asians did not generalize to the prejudice toward Aboriginals. Moreover, the TGT technique also includes an interdependence component, consisting of shared rewards and thus differing from the jigsaw technique. The TGT technique had generally positive but inconsistent effects on cross-racial friendship (DeVries et al., 1978).

The third type of strategy consists of providing education with content specifically designed to improve inter-group relations. For example, the *Sesame Street* program improved children’s receptiveness to out-groups, but only for Serbians and only on a limited number of measures (Fluent Public Opinion, 2008). Similarly, a course about gender relations and racism reduced modern racism in university students only on two of three sub-scales, and only one effect was maintained one year later (Hogan & Mallot, 2005). In addition, effects on prejudice were rather small, as illustrated by the moderate improvement in social distance toward out-groups (.27 on an 8-point scale) of pupils that read and discussed dramatic plays relating difficulties encountered by minorities (Gimmestad & De Chiara, 1982). To sum up, contact is not always sufficient, and may worsen the intergroup negative attitudes (Walker & Crogan, 1998). The findings of their study, among others, suggest that interdependence may be a crucial feature of successful interventions. Nevertheless, it is as a whole difficult to compare

properly the specific contributions of the three kinds of strategies, since the indicators are various and effect sizes are rarely provided.

The Sooner the Better? Possible Moderation by Age of Participants

Since most of the interventions had positive but modest effects, no clear differences between the studies can be drawn regarding the age of their participants. In addition, comparing them would be difficult, since they differed on content, indicators of success, length, and since effect sizes were often missing. Thus, here are reported differences between age groups within studies. Among the studies included in this review, only one found a clear moderating effect: the impact of reading and discussing dramatic plays relating difficulties encountered by minorities on social distance was highly significant ($p < .001$) for 4th graders only, and not for 5th and 6th graders (Gimmestad & De Chiara, 1982). Hallinan and Smith (1985) also found a tendency for higher impact of classroom composition on interracial friendliness for younger children (sample: 4th to 7th graders), but this effect was very inconsistent over the six time points of measurement.

Other studies have tested interaction effects between age and intervention. However, none of those were significant regarding inter-group attitudes, prejudice or friendship (Fluent Public Opinion, 2008; Wright & Tropp, 2005). The rest of the studies in this review did not mention the presence or absence of an interaction between intervention and age (Binder et al., 2009; Damico et al., 1981; DeVries et al., 1978; Hogan & Mallott, 2005; Oortwijn et al., 2008; Walker & Crogan, 1998). As a whole, the findings do not support the existence of a moderating effect of age. However, that does not mean that any intervention could work for any age, since the interventions which have been evaluated in the studies have been developed and adapted for the specific age groups they targeted.

Conclusion

The three types of strategies that have been presented in this paper – “simple” intergroup contact by desegregation, cooperative learning and content-based strategies – seem to have a generally positive impact on both interracial attitudes and interracial friendships. Nevertheless, the effects were modest and more research is needed to determine which features of the strategies are the most important. Some findings suggest that mere contact with out-groups is not enough and that interdependence is an important requirement for effective cooperative learning strategies. However, the analysis of moderators did not provide clear indications. Evidence was conflicting for the effect of minority versus majority status, whereas the evidence for moderation by age was scarce and often not conclusive.

The studies that have been presented above illustrate the vast creativity of program developers and a wide variety of strategies that can work toward the general goal of improving interethnic relations of students at the intergroup (attitudes and prejudice) and interpersonal (friendship) levels. However, these studies include some important methodological weaknesses, such as a lack of follow-up measures. Such measures were taken in only one study (Hogan & Mallott, 2005) among those presented in this review. Along with the small effect sizes found in the studies, this uncertainty about potential long-lasting impact suggest that we are far from having developed the panacea for problematic interracial relations in students. However, the studies reviewed above show that the interventions do have an impact on racial attitudes and cross-race friendships, at least in a short time frame and under certain conditions.

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The Association of Gene *DRD2* with Schizophrenia

Luc Cary

Introduction

This paper will outline the level of involvement of gene *DRD2* polymorphisms in schizophrenia pathogenesis by reviewing a collection of relevant association studies. In doing so, the paper will also demonstrate the inconsistent nature of gene research. Superficially, it seems impossible for a conclusion to be reached about a gene of interest. A discussion of the studies, however, will shed light on possible solutions to the issue of inconsistency.

Biological Mechanism

Gene *DRD2* encodes the D2-receptor located on postsynaptic neurons within the dopamine neurotransmitter system. By inhibiting adenylyl cyclase activity, the G-protein coupled D2-receptor modulates the transmission of extracellular signals into the cytoplasm (Neves, Ram, & Iyengar, 2003). The expression of gene *DRD2* has a direct impact on neurotransmitter signaling in dopamine pathways, which mediate motor activities, hormone production, drug addiction, and emotion. Thus, *DRD2* is a gene of interest for the treatment of neuropsychiatric and movement disorders.

Clinical Phenotypes Associated with *DRD2*

Dopamine, the brain's most prevalent catecholamine, has been widely studied using knockout animals (Vallone, Picetti, & Borrelli, 2000). For instance, mice homozygous for a knockout of gene *DRD2* (-/-) show reduced locomotion, backwards motion, and no vertical behavior in open-field tests compared to heterozygous mice (+/) (Balk et al., 1995). These and similar findings have prompted research on particular *DRD2* polymorphisms and their association with movement disorders. Klein et al. (1999) studied 8 family members with myoclonic dystonia (MD), a spasmodic movement disorder, who all had *DRD2* missense mutations. A missense mutation occurs if a single nucleotide is changed within the gene. This results in a mutated codon, which cannot code for the proper amino acid in the translation stage of protein synthesis. The above study suggested that a missense mutation in *DRD2* contributed to MD. A follow-up study showed, by direct sequencing of the 8 individuals' genomes, that they all had a deletion in their SCGE gene (Klein et al., 2000). The SCGE deletion has been previously associated with MD (Doheny et al., 2002). Since the follow-up study concluded

that *DRD2* mutations are rare in cases of MD, the role of *DRD2* in the disorder remains unclear.

Gene *DRD2* may affect thought processes in addition to movement. A behavioral disorder that is potentially associated with *DRD2* is schizophrenia, a mental disorder characterized by detachment from reality. Schizophrenics often report delusions, inappropriate thoughts, and inappropriate emotions, all of which elicit abnormal behavior. The dopamine hypothesis of schizophrenia attributes the positive symptoms of schizophrenia to hyperactivity within specific dopaminergic pathways (Flaum & Andreasen, 1994). This is still a hypothesis that has yet to be experimentally confirmed. On a behavioral level, schizophrenic symptoms mirror the symptoms of a cocaine or methamphetamine high. Under the above hypothesis, it is no coincidence that both cocaine and methamphetamine trigger dopaminergic hyperactivity. On a genetic level, polymorphisms of *DRD2* have been shown to affect the antipsychotic potency of neuroleptic drugs for schizophrenic patients, and the average number of D2 dopamine receptors in the brains of schizophrenics is higher than in healthy brains (Seeman, 1992).

The Research

Arinami et al. (1994) performed one of the most cited studies concerning the association between *DRD2* and schizophrenia. The study involved 156 Japanese patients that met the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders criteria for schizophrenia and a control group comprised of 300 Japanese individuals. It is important to note that this study was limited in sample diversity since it was only conducted in Japan. The partial genotype of every individual was assessed using a polymerase chain reaction (PCR). After amplification with *Taq* polymerase in a thermal cycler, the PCR products were analyzed using agarose gel electrophoresis. Although amplification with *Taq* can result in more errors than for other proofreading polymerases, the percentage of error is low enough as to be

statistically insignificant when testing for the frequency of a specific polymorphism. The case-control model and genetic method used in this study have been replicated in numerous subsequent association studies for the *DRD2* polymorphism (Arinami, Gao, Hamaguchi, & Toru, 1997).

The above Arinami study examined other variants as well. Cys311 is a polymorphism of *DRD2* in which codon 311 mutates from TCC to TGC. In other words, the variant gene contains a missense mutation of codon 311 in which serine is substituted for cysteine. Compared to the control group, the schizophrenic group was found to have a higher allele frequency of variant Cys311 (Arinami et al., 1994).

Arinami et al. reported frequencies of 3.6% heterozygous for the Cys311 variant in the control group versus 7.1% for schizophrenics, and 0% homozygous (Cys311/Cys311) in the control group versus 2% in schizophrenics. Furthermore, heterozygous schizophrenics were more likely to have a family history of schizophrenia (18% of the patients' parents had been treated for schizophrenia) than were schizophrenics without any Cys311 mutation (4%). Schizophrenics with the Cys311 mutation were reported to have less severe thought disorder, flattened affect, psychomotor retardation, and the total duration of hospital admission was shorter on average for schizophrenics with Cys311. These differences suggest that the Cys311 variant reduces positive symptoms and allows for a better response to antipsychotics. However, features of schizophrenia were also reported to be either similar or more pronounced in homozygous (Cys311/Cys311) than in heterozygous schizophrenics. The study concluded that the number of Cys311 alleles is proportional to genetic risk for the disorder (Arinami et al., 1994).

The association of Cys311 with schizophrenia gained attention after the Arinami study, and the variant was examined in many further experiments. Many subsequent studies failed to find such an association with schizophrenia for this particular

variant. An obvious but important observation is that although all individuals homozygous for the Cys311 variant are diagnosed schizophrenics, not all schizophrenics are homozygous for the mutation. Crawford, Hoyne and colleagues (1996) performed another case-control study within a Caucasian population with the same PCR technique used by Arinami. After testing with electrophoresis for the mutation, χ^2 analysis showed that Cys311 mutations not only occurred at similar frequencies for both schizophrenics and control groups, but also that the frequencies were statistically insignificant (Crawford et al., 1996). Thus the Cys311 polymorphism is rare to the point of insignificance, and the Arinami results were anomalous.

Arinami et al. (1997) returned to the lab to examine the 5' region of *DRD2*. If a Cys311 variant had no significant effect, then a mutation in the promoter region might affect the onset of schizophrenia and mediate the effect of antipsychotics. The genotyping procedure was similar to the aforementioned studies: amplified fragments underwent PCR-RFLP (restriction fragment length polymorphism) analysis, were then run on an agarose gel through electrophoresis, and subsequently visualized using ethidium bromide staining. χ^2 analysis of the data showed that the group difference for allelic frequency of polymorphism -141C *Ins* (an insertion-type mutation) was statistically significant: the mutation resulted in greater risk for schizophrenia (Arinami et al., 1997).

As with the Cys311 variant, many case-control studies refuted the association of a -141C insertion with schizophrenia. Hori, Ohmori, Shinkai, Kojima, and Nakamura (2001) found, by testing 241 Japanese patients and 200 Japanese controls, that neither the Cys311 polymorphism nor the -141C *Ins* polymorphism was associated with schizophrenia. This study was even more specific than the previous studies; not only were the genotypes between groups analyzed using Fischer's test, but the haplotype frequencies between groups were tested by χ^2 analysis. Haplotype frequencies

of both polymorphisms were calculated after estimating linkage disequilibrium. The conclusions reached by Arinami et al. (1997) regarding *DRD2* were refuted by the statistical insignificance of the differences in both the genotype and the haplotype (Hori et al., 2001).

The Cys311 and -141C variants are only two out of the considerable number of *DRD2* polymorphisms that have been researched. Recent association studies have discovered and investigated other polymorphisms such as the widely studied T-allele at the rs6277 SNP of gene *DRD2*. In a case-control study, the schizophrenic group had a statistically significant ($p=.034$) increase in frequency of the rs6277 T-allele compared to the control group (Fan et al., 2010). The rs6277 T-allele may increase genetic vulnerability to schizophrenia. This finding should be taken with a grain of salt, however, since a p -value of .034 might not be low enough to withstand scrutiny of other tests. A more robust association, for example, was found for a polymorphism at the rs6275 SNP (p -value = .011) (Gupta, Chauhan, & Bhatnagar, 2009). What's more, genetic risk is not the only feature examined in association studies. For instance, a polymorphism at the rs2734839 SNP has been linked with the age of onset for schizophrenia (Voisey, Swagell, & Hughes, 2011). Clearly, as research progresses, case-control studies will shed light on the association between the *DRD2* gene and schizophrenia and also provide information as to the specific role of *DRD2* in that association.

Discussion of Results

In addition to the rs2734839 SNP mentioned above, haplotyping experiments have found polymorphisms in gene *B2A2* that may determine the age of onset (Dubertret, Gorwood, Gouya, Deybach, & Adès, 2001). It is easy to forget that schizophrenia, if mediated by the dopamine system, can be influenced by the expression of any gene involved in the dopamine pathway. There also remains the possibility of genes associated with schizophrenia that have no involvement with

dopamine regulation. This all goes to say that genetic vulnerability for schizophrenia almost certainly involves polygenic inheritance; it is a trait controlled by more than two sets of alleles. It is for this reason that meta-analyses that aim to find genetic associations with schizophrenia examine many genes at once (Shi, Gershon, Liu, 2008). Also, supposing *DRD2* is associated with schizophrenia, it is not mutually exclusive for the gene to be associated with other phenotypes, such as MD, posttraumatic stress disorder, obesity, drug addiction, or migraines (Noble, 2003).

Despite many negative responses, there have been studies within Caucasian populations that support the -141C association found in the second Arinami study (1997). One such case-control study, by Lafuente et al., (2007), examined both genotypes and haplotypes in a Spanish sample and found statistically significant differences for -141C *Ins* between schizophrenics and controls.

Despite these confirmations, other more recent studies have differed methodologically from studies of the 1990s. The original Arinami study (1994) only used genotypes to determine distinctions between case and control groups. Modern case-control studies also contrast the haplotypes of the control and experimental groups. The haplotypes and genotypes of an organism contain the same alleles, but there is extra information about recombination within the haplotype data. Therefore, the Lafuente et al. (2007) and Hori et al. (2001) studies, which both analyzed haplotypes as well as genotypes, supported and provided additional information about the association of *DRD2* with schizophrenia compared to previous studies. Despite this, there is no concrete conclusion about such an association. The only general consensus is that findings across association analyses are "mixed and largely inconsistent," according to Fan (2010). A possible reason for inconsistency could be related to race. The race of each sample population is mentioned in the majority of abstracts of papers seeking associations between *DRD2* and schizophrenia.

Since the studies are conducted in different countries, perhaps race affects the results. Crawford et al.'s (1996) study was conducted with Caucasians, but refuted the results of Arinami's Japanese study (1994). Since genetic diversity depends on the location of sample populations around the world, the characteristics of each sample unavoidably affect the results of each study to some degree. Location could affect genetic variability from study to study, but this is not the only factor that could skew results in a study.

Meta-analyses provide many ways to delineate the influence of sample characteristics on effect sizes. By calculating the gender index and mean age, factoring in ethnicity, and adjusting for the proportion of case and control numbers, a fixed-effects meta-analysis can provide a more objective conclusion. Specifically, all of the sample characteristics can be factored into an odds ratio (OR). An $OR > 1.0$ suggests an association between an allele and schizophrenia, and the ORs for multiple studies can be pooled and assessed by χ^2 analysis for goodness of fit (Glatt, Faraone, Tsuang, 2003). A meta-analysis conducted by Glatt and Jönsson (2006) examined 24 past Cys311 studies. The fixed-effects result of the meta-analysis was an overall $OR = 1.38$ ($p = .002$). This result suggests a Cys311 mutation significantly impacts the genetic risk of schizophrenia. It is important to note that out of the 24 studies analyzed by Glatt and Jönsson, 21 reported no association of Cys311 with schizophrenia. So, despite the fact that 21 out of 24 studies concluded there was no association, a meta-analysis can conclude otherwise by minimizing the effects of gender, race, age, and sample size. If these factors truly skew the research conducted, then a meta-analysis of all studies provides a more accurate measure of allelic influence. The Glatt and Jönsson meta-analysis supports the overall involvement of the *DRD2* gene in schizophrenia pathogenesis.

Meta-analyses offer much in the way of reaching a conclusion, but there are other ways to effectively pinpoint causal variants. Many studies conclude

that the scientific community needs to provide more family-based studies in order to confirm the association between *DRD2* polymorphisms and schizophrenia (Glatt, Faraone, Tsuang, 2003). Family-based association studies allow researchers to track a direct line of inheritance through genetically related individuals. Since it is far more difficult to obtain genetic information from deceased persons than from living ones, population-based studies and unrelated case-control studies are far more common. Glatt (2003) discusses the scarcity of family-based studies on the association of the Cys311 allele with schizophrenia: “family-based studies of this association, of which only one currently exists (OR=1.7), should be considered a high priority if this association is to be confirmed, validated, and widely recognized” (p. 913). Since confirmation, validation, and recognition are clearly the ends that gene research attempts to reach, perhaps an increased effort to conduct family studies should be pursued.

Although the individual studies do not reach any unanimous conclusion, meta-analyses are powerful tools for delineating the influence of sample characteristics and finding patterns within the data. Also, a variety of sample characteristics is important for external validity, but a variety of study types is also important. Family studies are very useful for calculating genetic risk of inheritance, and can be contrasted with population-based studies for more accurate findings. The methods of modern gene research must continue to be refined in order to reach the ideal of a concrete conclusion for the association between *DRD2* and schizophrenia. What can be said at present is this: the apparent logic of the dopamine hypothesis, and the findings of the Glatt meta-analyses seemingly point to an association between *DRD2* and risk of schizophrenia. Only a more developed field of gene research will illuminate the accuracy of this association, the full effects of *DRD2* polymorphisms, and other relevant alleles in the pathogenesis of schizophrenia. Arinami T, Hamaguchi H, Itokawa M, *et al.* (1994). Association

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Sport Fandom's Relation to Flow and Its Adaptive and Maladaptive Behaviour

Domenico Tullo

Introduction

For as long as humans have been competing, there has always been a struggle to attain dominance in many domains including strength, intelligence, and willpower. The athlete best epitomizes this struggle for dominance. As athletes fight for supremacy, sports fans have gathered to offer their support for specific athletes (Delaney & Madigan, 2009). This unique behaviour leads to a number of questions: what are the typical characteristics of a sports fan and why do they devote their time, money, effort and emotions to showing support for athletes, when no monetary rewards or personal achievements are at stake? In describing the behaviour behind sports fandom, similarities to Csikszentmihalyi and Rathunde's motivational psychological theory of flow emerge. By examining the identity and motivations of sports fans, both adaptive prosocial behavior and maladaptive violent behaviour in this social domain become apparent.

Fan Behaviour and Their Function

On television, at live sporting events, and in our every day lives, sports fans can commonly be seen exhibiting extreme behaviours. They appear shirtless in frigid temperatures covered in

body paint. Some wear extravagant costumes and carry eccentric props, some participate in riots or celebratory parades, some spend their days listening to endless hours of sports talk radio and insider analysis on television, and others devote countless hours to rifling through internet discussion forums searching for other fans' opinions. This is the typical sports fanatic. Tim Delaney and Tim Madigan's (2009) book *Sports, Why People Love Them!* suggests that these fans can come from all socioeconomic classes, geographic locations, and be of all ages. The authors also suggest that these factors, along with ethnicity, aid a sports enthusiast to identify with a certain athlete or sports team (Delaney and Madigan, 2009). Generally the sports fan will tend to support such athletes or sports teams that share common values and beliefs with them, and thus the athlete may be seen as a vehicle representing the fan's principles (Edwards, 1973). Consequentially, the fan's belief in those principles might be strengthened or weakened depending on the success of the supported athlete or team. According to Harry Edwards (1973) in his book *Sociology of Sport*, the statistical win or loss is irrelevant, but the act of losing to another athlete or sports team of another city, social class or race which represents contrasting principles,

can negatively impact the sports fan. The statistical loss can be seen as one's beliefs, values and culture being defeated, symbolizing its inferiority. Beyond the representation of one's belief, sports fandom has an effect on one's emotions.

Choosing to support an athlete or sports team may help to rid the individual of apathy with regards to the monotony faced in every day life, by eliciting emotions of excitement and disappointment (Edwards, 1973; Wann, Beverly & Rochelle, 2004). In identifying the sports fan, demonstrating their characteristic behavior, and assessing their emotional component, sports fandom can be seen as a highly pleasurable and self-stimulating behavior. This intensity of reward can potentially motivate an individual to continue pursuing this activity despite a lack of any monetary, or other extrinsic rewards.

Csikszentmihalyi and Rathunde's Concept of Flow

Sports fandom is continuously reinforced through enjoyable and self-gratifying behaviour. This phenomenon can theoretically be tied to Csikszentmihalyi and Rathunde's concept of flow. Csikszentmihalyi and Rathunde (1993) describe flow as the pleasant state unique to an individual where one is completely entranced in an intrinsically motivated activity. The multiple components of flow begin with setting clear goals coupled with receiving immediate feedback. Other components of flow are engaging in tasks with a high level of difficulty, enacting automatic movements, focusing solely on the task at hand, disconnecting with reality, the self, and time, and having an automatic drive to experience the activity (Csikszentmihalyi & Rathunde, 1993). Through further examination, similarities between a sports fan's behaviour and the components of flow emerge.

The relation between sports fans and Csikszentmihalyi and Rathunde's first component of flow, having clear goals along with receiving immediate evaluation, can theoretically be seen through the

sports fan's desire for the success of their favourite team or athlete. In order to fulfill the sports fan's need for a winning culture their supporting athlete or team must have a tendency to win. Rainey, Larsen and Yost's (2009) study on baseball fans' emotions demonstrated that, through sincere dedication to a sports team or athlete, the average sports fan can achieve both the high and low points of emotion. Supporting a successful team reinforces the fan's self-image and self-worth with feelings of happiness and satisfaction (Edwards, 1973; Rainey et al., 2009). In contrast, when the average fan faces failure and disappointment through the disappointing outcomes of a game or match, this can cause the supporter to feel as if his personal values and beliefs have taken a significant loss (Edwards, 1973). This significant loss, according to Rainey et al. (2009), elicits feelings of anger and disappointment in the fan and in the long run, can lead to discouragement. Continuous defeat can lead to a depleted fanbase due to the failure of the athletes to reinforce fan values (Edwards, 1973; Rainey et al., 2009). The sports fan therefore sets the clear goal of his or her sports team or athlete winning and the fan is then given immediate feedback on the sporting event's outcome. The self-stimulating and pleasurable emotions resulting from one's team winning might be seen as a behavioral reinforcement for one's underlying wishes and desires (Edwards, 1973; Hillman et al., 2000). These hidden desires brought out by sports fandom play a significant role in why this activity, according to Csikszentmihalyi and Rathunde (1993), is rewarding to the individual. In setting these clear goals and continuously receiving immediate feedback from the athletes, the sports fan might evolve and develop new activities and or strategies in the pursuit of a winning culture.

As the individual's favored sports team or athlete continue to achieve success and reinforce the fan's values, this may cause the individual to generate a sense of personal attachment and personal involvement in the competitors, which in turn, requires particular skills and challenges that increases the fan's sense of association with the

sports team.

This leads to Csikszentmihalyi and Rathunde's (1993) proposed second element of flow: challenges and skill development. According to Hillman et al.'s (2000) study on fan association, as the athlete or sports team continues to succeed and elicit positive emotions from the sports fan, the fan will begin to feel a strong association with their beloved competitors by referring to themselves (the fan and the team of athletes) as the collective unit of 'we'. The use of this pronoun, which strengthens a fan's connection to the sports team, can be seen as a link to the activities that these fans engage in. Activities, such as wearing the team uniform, provide a sense of direct participation with the athletes as well as a connection with other supporters of the same team (Aden et al., 2009). As a fan's connection with the sports team is augmented through these activities, the fan may feel pressured by other fans to adopt increasingly challenging actions, which require the acquisition of unorthodox skills (Csikszentmihalyi & Rathunde, 1993). For instance, when rival fans threaten one's values and beliefs, an outbreak of violence, or more commonly, verbal taunting may occur (Wann, 2006). The fan is required to defend and protect their values through this behaviour, which instills a greater sense of attachment to the team (Edwards, 1973; Hillman et al., 2000). As the fan engages in these protective behaviours (which, coincidentally, increases their association to their athletes) the fan may look for new challenges or ways to interact with other fans to further increase their association with the sports team. (Csikszentmihalyi & Rathunde, 1993). This association may require an increase in social skills as the sports fan may now connect with other fans through internet-based discussion forums (Aden et al., 2009). Therefore, an increased affiliation to a sports team might lead to the creation of elaborate team involvement challenges in order to seek a greater level of association with the desired team, which in the end, requires growth of different social skills. Csikszentmihalyi and Rathunde (1993) argue that the refinement of skills through the introduction of challenges is what induces

motivation and enjoyment in this activity. This increased motivation reinforces the sports fan's behavior, which later becomes automatic.

Once a sports fan becomes considerably attached to their team or athlete, certain practiced behaviours might become automatic or ritualistic. This ritualistic complex stems from the consequences of fandom being a pleasurable experience. Sigmund Freud's pleasure principle theory states that once one's basic biological needs are satisfied people concentrate on goals centered on personal achievement. According to Delaney and Madigan (2009) this theory can be used to describe sports fandom as being a "hedonistic concept" (p. 157). Thus, absorption in a sporting event can be seen as occurring naturally to the veteran sports fan. This ritualistic practice affects one's emotions and may provide a sense of pure concentration. Sports provide a pleasurable distraction from mundane or even stressful events that a sports fan may choose to escape through complete immersion in sporting events (Delaney & Madigan, 2009; Edwards 1973; Wann et al., 2004). However, even though sporting events entrance sports fans, these fans are not in direct control of the outcomes. One aspect of Aden et al.'s (2009) theory on personal rituals is that ritualistic participation may cause the fans to have a vicarious experience. This illusion of control coupled with an escape from reality through ritualistic and programmed exercises complies with the component of flow regarding automatic behavior. Once an activity becomes automatic, one is completely focused on the task at hand and is no longer aware of the self nor of the time elapsed (Csikszentmihalyi & Rathunde, 1993).

A significant benefit of participating in communal activities is to create a sense of identification with other group members. Fans can relate to other group members by wearing the same team uniform, by going to the extreme of painting their whole body or by wearing elaborate costumes. This sameness defies the North American norm of being unique; therefore one would normally struggle to avoid this situation (Iyengar & Lepper,

1999). Nevertheless, in this group activity, the fan feels as if they are actually participating in and influencing the sporting event (Aden et al., 2009). When entranced by a sporting event, there are times when a fan may participate in an embarrassing activity and are ambivalent as to how they are perceived by others. The fan's lack of self-awareness allows for focus to the task at hand, which improves performance, pleasure and significantly strengthens one's motivation to take part in an activity later on (Csikszentmihalyi & Rathunde, 1993). As well as a loss in self-consciousness, cheering on athletes at a sporting event or on a TV program, sports obsessions have an effect on a fan's sense of time. ESPN recently demonstrated this phenomenon by measuring how long sports fans can continuously watch sports (Delaney and Madigan, 2009). Participants easily surpassed a complete day of consistently watching sports, which suggests a lack of temporal-awareness when watching sports (Delaney & Madigan, 2009). Csikszentmihalyi and Rathunde (1993) argue that the importance of being unaware of time when focused on an activity is essential to increasing the reinforcement value of an intrinsically motivating activity. The loss of one's self-awareness suggests how pleasurable and stimulating sports can be. As a result this may cause one to constantly search for this activity (Csikszentmihalyi & Rathunde, 1993). Being that sports fandom provides an individual with pleasure, social interaction and a reinforcement of their beliefs, theoretically, one will continue to pursue this activity. Through persistency in fan behaviour, partisans may engage in adaptive and maladaptive behaviours.

Maladaptive and Adaptive Behaviour

Further examination of a sports fanatics' conduct can show adaptive and maladaptive behaviours precipitated by their intense identification with an athlete or team. Most noticeable are violent acts committed by sports fans. As in Jerry M. Lewis' (2007) book *Sports Fan Violence in North America*, sports fandom can take an ugly turn when vi-

olence, vandalism and hooliganism affects a city in celebration or frustration. Moreover, this violence can be expressed between rival fans through threatening behaviour. In order to defend one's values, a sports fan may attack rival fans verbally or in some extreme cases physically (Edwards, 1973). Furthermore, Csikszentmihalyi and Rathunde (1993) argue that one of the dangers of flow is developing an addiction to an activity rich in flow. Therefore, because sports fandom can be seen as an activity that elicits flow, its addicting aspect acts as an anxiolytic and negatively reinforces the individual in escaping undesirable and stressful situations. (Delaney & Madigan, 2009). However, sports fandom can offer pro-social benefits, which may apply to the more common casual fans

Typical sports fan behaviour might be beneficial to an individual's health. While participating in a flow activity such as sports fandom, one's self-esteem will increase (Csikszentmihalyi & Rathunde, 1993). Also, through ritualistic behavior from participating on discussion forums to voicing one's opinion on call-in radio programs, sports fans develop interpersonal skills (Aden et al., 2009). In the same way minor community leagues were created in the hope that children to remain out of trouble (McHae, Vinden & Bush, 2005), sports fandom offers itself as a pass time in place of crime (Delaney & Madigan, 2009). Along with the escape from crime, sports may add emotion and excitement to one's dull life (Wann et al., 2004).

Conclusion

The sports fan's behaviour intended to defend one's personal values, morals and ritualistic practices is closely related to the concept of flow (Aden et. al, 2009; Edwards, 1973). Similar to the conditions of flow, sports fandom comes with clear goals followed by immediate feedback. In addition, sports fans experience the absorption and control over a task that allows one to lose their sense of self, and their sense of time in order to pursue this activity intrinsically (Csikszentmihalyi & Rathunde, 1993). This pursuit however, can result in mal-

adaptive behaviours including extreme case of violence, but may result as well in adaptive behaviours that provide pro-social benefits (Aden et al. 2009; Csikszentmihalyi & Rathunde, 1993; Lewis 2007). Ultimately, the sports fan struggles to overcome a personal conflict between his or her pleasurable emotional ties to sports and the irrational and destructive mal-adaptive effects it has on both the self and society.

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A Review of Self-Determination Theory: Its Current and Future Directions in Health Behaviour Change

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Introduction

Self-determination theory (SDT) is a complex of human motivation that focuses on personality development, non-conscious processes, self-regulation, psychological needs, goals, and well-being (Deci & Ryan, 2008). SDT was extensively examined in the mid-1980s by Edward Deci and Richard Ryan and has since been applied to the study of many fields including health behaviour change, which is the subject of this paper. At its core, SDT focuses on autonomous motivation, which is described as intrinsic motivation and a sense of volition. While controlled motivation, related to external regulation, is based on rewards or punishment (Deci & Ryan, 2008), intrinsic motivation is based on an innate tendency to seek out novelty and challenges (Ryan & Deci, 2000). Furthermore, it has been shown by Ryan and Deci (2008) that SDT-based techniques work at both the conscious and unconscious levels. On the conscious level, self-regulation, otherwise known as self-control, is a huge determinant of effective self-determination.

Self-control, as discussed by Baumeister, Vohs and Tice (2007), is an individual's capacity or ability to alter his or her response in order to reflect ideals, values, morals, and social expectations. Ultimately, self-control is used to support long-term goal

attainment. Unfortunately, low self-control, is associated with impulsive and problematic behaviour. In addition, it has also been associated with unhealthy or risky health behaviours (Baumeister et al., 2007). Although self-control is a limited resource (Baumeister et al., 2007), overtime our self-control can adapt and increase will-power.

While high levels of self-control are an important factor in effective SDT-based techniques, Deci and Ryan (2008) maintain that there are basic and universal psychological needs that all humans share: autonomy, competence, and relatedness. Autonomy refers to feeling that one's activities and beliefs are connected with the self, competence is the idea that one can achieve a desired outcome, and relatedness is associated with feeling connected with others (Reis, Sheldon, Gable, Roscoe & Ryan, 2000). Ryan and Deci (2000) found that conditions that fostered these psychological needs generally increased human growth and internalization more so than situations that prevented these needs from being fulfilled. It is important to note that there is a significant difference between being internally motivated, valuing the activity or making a choice, and being externally motivated, feeling as though one is being coerced. Authentic motivation increa-

ses interest, excitement, confidence and general well-being (Ryan & Deci, 2000).

Overall, SDT has many applications and this research review will investigate how various health behaviours including exercise and weight management, smoking cessation, diabetes self-management, and treatment adherence are affected by SDT-based techniques based on evidence from randomized clinical trials (RCTs). Furthermore, motivational interviewing, a direct application of SDT, will be discussed, including its advantages and disadvantages for certain health behaviour changes. Finally, a discussion of the implications of these works will be considered.

A Review of Health Behaviour Interventions Based on Self-Determination Theory

Exercise and Weight Management

Physical activity is known to have many beneficial and protective effects on an individual's mental and physical health (Warburton, Nicol, & Bredin, 2006). Consequently, as many people adopt physical activity into their routines, researchers have found it important to investigate the motivational background behind this behaviour. Weight management largely depends on two health behaviours: eating and exercise. Mata et al. (2011) performed a 1 year RCT where 239 overweight or obese women participated. The focus of the study was promoting physical activity and intrinsic motivation in order to maintain successful weight loss and exercise. Exercise helps to improve self-efficacy, body image, and mood, and it promotes greater motivation and confidence (Mata et al., 2011). The authors of the study predicted that these positive outcomes of physical activity would essentially spill over and improve eating self-regulation and help with weight maintenance. Not only did they discover a positive relationship between increased self-regulation and physical activity, but they also concluded that exercise-specific motivation contributed to an overall improvement in eating behaviours, independent of

the fact that there are many positive physiological changes associated with exercise adoption. Moreover, Mata et al. (2011) associated the success of the SDT intervention with the importance of intrinsic motivation and autonomy.

Another study performed by Edmunds, Ntoumanis, and Duda (2005) found that people who already engaged in physical activity by regularly attending classes, perceived that they received autonomy support from the class leader. Autonomy support refers to the feeling that someone understands one's choices and goals. Furthermore, perceived autonomy support was found to be positively related to the three basic needs of self-determination motivation: autonomy, competence and relatedness. Exercise and weight management require self-control and, as shown by Edmunds et al. (2005), behaviour fostered by SDT aid in making positive changes possible.

Smoking

Similar to the significant impact SDT techniques has on exercise, they have a strong impact on smoking cessation and diet as well. Williams et al. (2006) states that individuals who feel autonomously motivated and freely choose to quit smoking experience volition and are dedicated to improving their health, rather than quitting because of external demands. Once again autonomy support provided by physicians was the mechanism behind the observed behaviour change, which ultimately influenced success. Williams et al. (2002) planned to perform a clinical trial to test whether SDT would positively impact smoking cessation and diet for individuals with elevated cholesterol. Participants in this study were 18 years or older and smoked at least five cigarettes per day. Participants were assigned to either an intervention or control condition. The intervention condition involved a 6-month period where participants met with counselors who promoted autonomous motivation and support. By emphasizing patient autonomy, this study anticipated that patients would feel motivated and self-determined to not only quit smoking and improve

Cessation

their health, but to also maintain this behaviour.

Williams et al. (2006) performed another study analyzing the difference between intensive interventions and community care on smoking cessation in Rochester, NY. Individuals in the community care condition received booklets on smoking cessation and were advised to make an appointment with their physician in addition to enrolling in a smoking cessation program. Individuals enrolled in the intensive intervention were offered the same material, however, they were also asked to meet with a counselor four times over a six month period. Overall they found that the intensive intervention condition promoted greater autonomy and competence support, and individuals in the intensive intervention condition experienced greater levels of successful smoking cessation than those in the community care condition. Both of these studies exemplify that SDT techniques provide both the counselor and the patient with the necessary tools to facilitate the smoking cessation success, which is true for diabetes self-management as well.

Diabetes Self-Management

Type II diabetes often develops due to unhealthy and risky behaviour choices (Vijan, 2010). However, once a person develops this disease he or she can prevent some of the negative effects by engaging in proper self-management. Self-management is the individual's active participation in glycemic control, or blood glucose levels. Williams, McGregor, Zeldman, Freedman, and Deci (2004) performed a longitudinal RCT that assessed SDT and its impact on glycemic control. The study used two treatment groups: the activation condition, which involved the patient taking greater initiative during a provider visit as well as a second group, where the researchers simply provided education on glycemic control. Competence in this study was defined as the patient's ability to control their glucose levels. Autonomy was described as the patient's ability to decrease his or her own calorie intake. A patient's perception that he or she initiated and mastered

the appropriate behaviour to accomplish is the fundamental idea of SDT. A patient activation approach was used to encourage patients to have more responsibility in their health outcomes as a direct result of the counselor's support for autonomy and competence. The researchers hypothesized that perceived autonomy and competence would predict successful diabetes self-management behaviours over a 12 month period. Williams et al. (2004) found that autonomy and perceived competence predicted improvement in glycemic control, as well as positive diabetes self-management behaviour over the study's 12-month experimental period.

Treatment Adherence

Unfortunately, many medical adherence interventions are ineffective and it is essential to find an appropriate solution to efficiently impact a patient's behaviour and opinions towards adherence. Adherence is defined as the extent to which a patient complies with a medical regimen as prescribed by their physician (Osterber & Blaschke, 2005). Successful interventions use specific theoretical approaches such as technical, behavioural, and educational approaches (Dulmen et al., 2007). Technical approaches rely on simplifying the medication regime by targeting dosage and packaging; these approaches have proven particularly effective in patients with diabetes. Behavioural techniques employ reminders and monitoring that allow for adequate feedback and support. Finally, education focuses on teaching with the ultimate goal of providing the patient with the tools to manage his or her disease (Dulmen et al., 2007). As SDT techniques promotes autonomous and competent strategies, SDT-based treatment adherence methods may help improve the patient's intrinsic motivation to change their health with regards to their medical regimens. Williams et al. (2006) argue that individuals feel more autonomous if they believe that they are taking medicine based on free choice, helping them reach their health goals.

Motivational Interviewing

Motivational interviewing, described by Miller in 1983, is a counseling style that attempts to change human behaviour based on addressing casual attributions, cognitive dissonance, and self-efficacy. Because a theoretical framework does not presently exist for motivational interviewing, Markland et al. (2005) proposed that SDT could provide a structure for this treatment. Motivational interviewing draws on a human's innate drive for personal growth and psychological integration. It focuses on enhancing intrinsic motivation, which is one of the central ideas of SDT. This form of counseling assumes that clients have conflicting motivations but have reasons for wanting to change their health behaviours. As mentioned previously, SDT makes the assertion that coercion or control is an ineffective way of promoting motivation. Consequently, motivational interviewing focuses on helping, guiding, and providing autonomy to people, rather than forcing the client to resolve their conflicting motivations. Furthermore, it promotes the internalization and integration of new behaviour, so that the client feels more inclined to resolve their conflicting feelings and feel more connected to the greater goal. It is crucial that the client feels he or she has full responsibility for their decision of whether or not to change their behaviour. Finally, relatedness is achieved by the counselor's expressed interest, warmth and support. Motivational interviewing is still a relatively new method and needs more research. However, a potential implementation of this technique would be to apply it to health behaviour intervention programs that already rely on SDT as the fundamental mechanism.

Discussion: The Future of Self-Determination Theory in Health Behaviour Change

Self-determination theory, as outlined by Ryan and Deci (2000), emphasizes that all humans share a basic set of psychological needs: autonomy, competence, and relatedness. The purpose of this paper was to analyze the experimental applications

of SDT. Evidently, there are many benefits to this approach, especially pertaining to behaviour change. Further research should be done on SDT-based interventions to determine whether they ought to or can be adopted into our medical systems in terms of successful behavioural interventions. Although SDT is a developing theory, many researchers (such as Williams et al., 2002; 2004; 2006) have investigated it extensively and have shown that SDT can be applied to many health behaviour changes. These changes include: exercise and weight management, smoking cessation, diabetes self-management, and treatment adherence. These need be addressed, with a special emphasis on prevention and intervention, as they are important everyday issues in our society. In the last decade, motivational interviewing has been successfully integrated with SDT as an efficacious form of counseling. Patients could greatly benefit from an implementation of SDT-based techniques and motivational interviewing in counseling that focuses on health behaviour change. A collaboration of this kind may strengthen the programs' success rates and provide counselors or physicians with an extra tool to meet their patients' needs. Self-determination theory is a very valuable technique that has the potential to significantly influence the future of medicine and counseling.

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Space in Sound: Human Active Echolocation

Sasha Ilnyckyj

Introduction

The use of self-generated acoustic emissions by animals as a means of perceiving and localizing objects within their environment is a well-studied phenomenon. Through acoustic comparison of a perceiver-generated wavefront (pulse) and its reflection off a surface (echo) an organism can access information on the spatial characteristics of its surroundings. This form of auditory-spatial perception, known as echolocation, was first identified in 1938 by zoologist Donald Griffin. At Harvard University, Griffin became intrigued by the mechanisms underlying bat navigation, particularly after reading “elementary accounts of Spallanzani’s experiments showing that blinded bats flew normally” (Squire, 1998, p. 73). His own subsequent investigations (Griffin, 1940) confirmed ultrasonic ranging as the basis of bat navigation and earned him the reputation of the pioneer of echolocation research. Since then, observation and documentation of the echolocative capacities of bats (see Simmons, 1989 for a review) as well as porpoises (Kellogg, 1961), whales and select terrestrial mammals (Stoffregen & Pittenger, 1995, p. 182) have contributed to the formation of a sophisticated and ample body of literature.

One species that is not an immediately obvious user of echolocation is our own. However, it has

been demonstrated that both blind and sighted people can, and do, utilize this form of perception (Ammons, Worchel & Dallenbach, 1953; Kay, 1974; Kellogg, 1962; Rice, 1967; Teng & Whitney, 2011). In fact, echolocation may play a far more prominent role in human spatial perception than is generally supposed. This paper seeks to illuminate these capacities through a brief review of current knowledge on the topic of human active echolocation. Following this, potential mechanisms and sources of information that underlie particular discriminative capacities will be presented in reference to specific experiments. Finally, this paper will discuss modern perceptual aids, the product of a dynamic discipline combining engineering and psychology. It is from this point that suggestions about future directions in the field will be elaborated.

Where the Field Stands: Human Echolocation in the Literature

For those involved in the field of perceptual psychology, human active echolocation may not be a completely alien concept. Anecdotes involving blind individuals riding bicycles (Rosenblum, 2009) and playing sports (Blackstone, 2009)

are present in many lectures and textbooks on human perception. Indeed, echolocation has found its place even within popular culture. For instance, Marvel Comic's super-hero Daredevil, rendered blind in a radioactive accident, is bestowed with enhanced perceptual powers enabling him to fight crime. What these examples demonstrate is a general awareness of the use of sound to characterize space. What they do not demonstrate is an empirical, quantitative approach to understanding these capacities. This section will outline the history of such investigation.

The first observation of retained spatial perception in blind people was by French philosopher Denis Diderot in the 18th century. Diderot (1789) described astonishment at a blind acquaintance's "amazing ability" to perceive and avoid objects. Numerous theories arose to explain this phenomenon¹, the foremost of which was the facial vision hypothesis. Proponents of this theory attributed blind spatial perception to an enhanced tactile acuity on the skin of the face. Hyper-sensitivity to perturbations in air currents, temperature and pressure could hypothetically guide navigation. While in retrospect this may seem ponderous, there is a certain sophistication in this theory of somatosensory enhancement. It acknowledges perceptual gains often observed in preserved modalities when individuals lose a sense – so called sensory substitution (e.g. Rauschecker, 1995). The facial vision theory of object detection would remain popular for two centuries.

Empirical investigation of obstacle detection by the blind began in the 1940s. Supa, Cotzin and Dalenbach (1944) performed a series of experiments on spatial discrimination abilities in the blind. By systematically disrupting either facial tactile sensitivity or auditory sensitivity, they proved that it was auditory perception of echoes reflected from surfaces that enabled obstacle detection when approaching a vertical board. As such, they effectively disproved the facial vision hypothesis and demonstrated audition to be the modality underlying detection. Ammons et al.(1953) replicated the

findings of the Cornell studies conducted by Supa with two interesting distinctions. Firstly, they addressed potential issues of ecological validity by performing the experiment out-of-doors, in the presence of ambient noise and environmental distractions. Secondly, the participants were sighted individuals. Their findings were congruent with Supa et al., demonstrating a high degree of task competency despite their differing design and experimental group.

Arias (1997) identified "two basic modalities" of human echolocation. The first involves simple detection of obstacles within the environment, whereas the second is concerned with discriminating physical characteristics of that which is detected. With detection proven (Supa et al., 1944; Ammons et al., 1953), research in the 1960s turned its focus to the second modality in hopes of identifying particular object features discernable through echo perception. Kellogg (1962) was the first to apply traditional psychophysical techniques and obtain quantitative measures of echo-perception. In a series of experiments, it was demonstrated that individuals could reliably detect differences in object distance, texture and size. Importantly, they reported that, while blind subjects tended to excel, sighted subjects rarely performed above chance. However, a series of studies performed in subsequent years suggested that echo-perception was not unique to the blind. Rice (1967) found both blind and sighted people (to a slightly lesser extent) are able to detect targets monaurally, to discriminate simple shapes and to locate targets in space. Other experiments on sighted subjects confirmed findings of obstacle detection (Ammons et al., 1953), simple shape and texture discrimination (Hausfeld, 1982), and accurate spatial localization (Teng & Whitney, 2011)². In fact, it seems Kellogg's (1962) findings of chance performance in sighted subjects represent the exception. It appears that with little training both blind and sighted subjects can localize objects and perceive specific physical characteristics. General observations common to the studies above include:

i. Quantitative results that were highly consistent with psychometric functions observed in other sensory modalities for detection tasks, generally appearing sigmoidal (see Figure 1). This is true of both blind and sighted participants.

ii. Ceiling performance was rapidly achieved. For instance, Hausfeld (1982) observed near-optimal performance by trial block number two of ten with little subsequent improvement thereafter. Also noted by Rice (1967) and Teng and Whitney (2011)

iii. Certain tasks proved more difficult than others – for instance, discrimination of size was far worse than that of texture, distance or position (Kellogg, 1962)

iv. Blind subjects consistently outperformed the sighted. However, exceptional skill was observed in some sighted participants. Teng and Whitney (2011) reported on a naive sighted subject whose precision approached that of a congenitally blind expert.

v. Large variations in individual performance were observed despite normal audiometric profiles in all participants. Firstly, individual techniques differed between subjects. For instance, when generating pulses, most subjects employed either discrete clicks or prolonged hissing but other pulse varieties were often reported³. Furthermore, it is likely that pre-existing aptitude differences existed as well, evidenced by the high degree of performance stability within subjects.

vi. Blind participants spontaneously produced exploratory head motions, a behaviour absent among the sighted. Interestingly, this behaviour has also been observed in porpoises as they perform undersea ranging (Kellogg, 1959; Norris et al., 1961). Deemed auditory scanning it is thought to combine echo ranging and binaural localization. The lateral head oscillations help accentuate the differences in echoes received between the two ears by continuously modulating the inter-aural

intensity and phase differences (Kellogg, 1961),

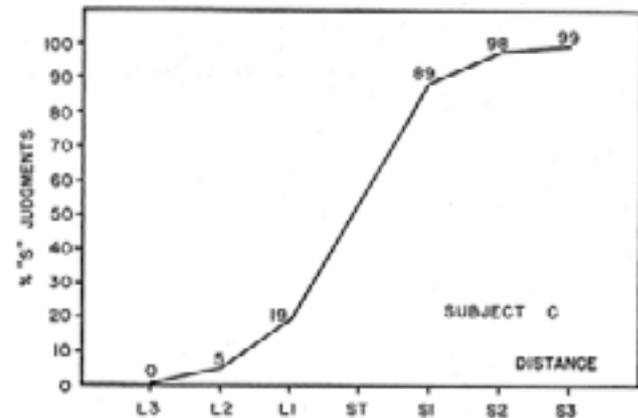


Figure 1. Psychometric function as a subject on distance discrimination paradigm (Kellogg, 1962, p.401)

Proposed Mechanisms Underlying Echolocation

The body of literature summarized above demonstrates empirically that humans do possess echolocative capabilities. As the study of auditory perception has progressed so too has our understanding of the physics of sound. While this paper does not endeavour to address the complex mathematics of acoustic interactions, a practical understanding of the mechanics relevant to echolocation is fundamental to appreciating this modality. This section will address how distance, texture, size and motion can be coded in sound. Each description will be supplemented with reference to experimental paradigms. Lastly, the use of intermodal cues in auditory spatial perception will be acknowledged.

Distance Discrimination

Capacity to detect distance is of primary importance to any perceptual system involving spatial relations between an observer and his surroundings. This is accomplished by comparing stimulus characteristics of a self-generated pulse with those of its echo. The result is a representation of physical surroundings in the form of an object space. The most immediately obvious cue of distance is that of the pulse-to-echo (P-E) delay (Stoffregen & Pittenger, 1995). Essentially,

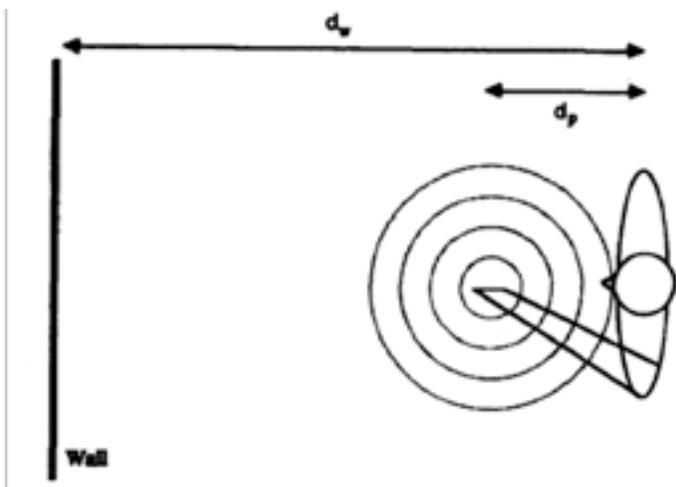


Figure 2. A schematic diagram demonstrating the principal of Pulse-Echo Delay (Stoffregen & Pittenger, 1995, p. 188).

assuming the speed of sound through air to be relatively constant⁴, the time delay between when the original pulse and its echo are perceived is a function of the distance between the reflecting surface and the ear.

Consider a situation in which a person facing a reflecting surface (wall) snaps his or her fingers with their arm at distance d_p in front of them.

Let d_p = distance from pulse's point of origin to ear, d_w = distance from wall to ear and c = speed of sound through air

timepulse (time it takes the pulse to reach the ear) = d_p/c

timeecho (time it takes for the pulse to reach the wall and reflect back to the ear) = $(2d_w - d_p)/c$, as wave must travel from pulse source to wall and back

P-E delay = $t_e - t_p = 2(d_w - d_p)/c$
 $d_w = [c(t_e - t_p)/2] + d_p$ (see figure 2)

Thus, the distance to the reflecting object, d_w , can be derived if information regarding the distance of the original pulse source from the ear and the speed of sound are accessible. For humans performing echo-perception, pulses are generated as

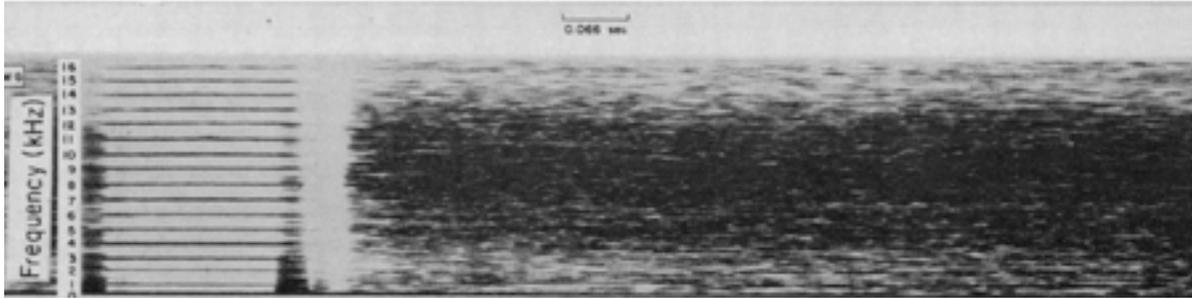
utterances from a consistent location (i.e. the vocal tract) at a well-known distance from the ears. To calibrate the speed of sound, Stoffregen and Pittenger (1995) acknowledged the necessity of an intermodal cue. For instance, the delay between when a perceiver feels the somatosensory feedback of producing a vocal click and the pulse's arrival can disambiguate the speed of sound⁵. P-E delay is well-demonstrated in Kellogg's 1962 distance-discrimination paradigm. Subjects were asked in a paired comparison whether the second of two identical wooden disks was located nearer or further than the first placed at a standard distance (two feet). A more distant test disk would generate a larger P-E delay. Subjects demonstrated extremely high sensitivity to very minute delays, in some cases on the order of approximately 0.0003 s.

A second fundamental cue in distance discrimination is based upon the frequency relations between pulse and echo (see Wilson, 1966). Clicks and hisses are both broadband noises containing a wide range of frequencies within their spectra (see figure 3). If two sound waves are in phase with one another, an amplification effect is observed that increases the intensity of sound at their shared frequency. Thus, at various distances different frequency components of a pulse would be enhanced by the echo, resulting in specific increases in the perceived loudness of those components.

That distance is represented by:
 $d = c/2f$, where f is a given frequency

Bassett and Eastmond (1964) were among the first to investigate the phenomenon in which a predominant pitch arises through the interaction between a pulse and echo. This pitch varies with distance from the reflecting object. Participants held a speaker outputting broadband noise while a pure tone was played through a second distal speaker. Facing a reflecting panel, they were instructed to listen within the broadband noise for the predominant pitch that emerged. Once identified, subjects had to walk towards or away from the board until the emergent pitch matched the pure tone

Figure 3. The frequency spectrum of a human hiss. Similar to 'white noise', it contains a wide range of frequency components (Y axis) over time (X axis) (Rice, 1967, p.660).



sample. They found that the distance considered to match the pure tone was accurately predicted by the equation above. Thus, if frequency component amplification exists in a fixed relationship with distance, the frequency relations between a pulse and echo could certainly cue distance.

The cue discussed above was discovered by Thurlow and Small (1955) and is known as a repetition pitch or rippled noise pitch. It was observed that when individuals listen to a pair of identical trains of pulses slightly offset in time, a pitch emerged that was “equal to the reciprocal of the smallest time separation between leading edges of proximal pulses of the two trains.” (Arias, 1997) An echolocative pulse and its echo are likewise identical sound stimuli slightly offset in time. The tone that emerges as a result of pulse-echo interference varies inversely with distance as some frequencies are cancelled and others enhanced. This cue is evidenced by Ammons et al. (1953) who reported that blindfolded subjects experienced “a change of sound in their footsteps” as they approached a vertical board. Presumably, if interference patterns can be detected in discrete sonic events such as footsteps, a continuous signal would provide an even better cue. For this reason, Arias (1997) posits that continuous broadband hissing should provide the best signal. To date, however, no comprehensive comparison has been performed to test this.

Texture Discrimination

Another object feature that can be readily discriminated using echo-perception is texture.

The physical composition of objects determines their sonic absorption properties such that some frequencies will be absorbed and others reflected. By comparing the relative frequency spectra of pulse and echo, texture is disambiguated. Rigid surfaces such as glass will reflect more high frequency waves while soft surfaces such as cloth tend to reflect the low. Kellogg (1962) had individuals attempt to discriminate between six equally sized disks made of various materials (glass, painted wood, denim, velvet, metal and plain wood). In paired comparisons, subjects could discriminate sixteen of the twenty-one combinations at an average accuracy of 94.5%. Only in pairs of substances with similar densities (e.g. glass and metal) was performance at chance.

Texture discrimination provides another explanation for the popularity of clicks and hisses in echo-perception. Both pulses employ broadband noise which would provide a diverse sample of frequencies across the spectrum. By observing which spectral aspects are attenuated through absorption, a clear idea of an object's composition can be determined.

Size Discrimination

The cue that is most fundamental to discriminating the size of a reflecting object is the relative intensity of the pulse and echo. Larger obstacles occupy more space and will therefore reflect a greater amount of acoustic energy. That being said, Kellogg (1962) found that subject performance was far worse on tasks involving the discrimination

of different sized disks at a fixed distance than on tests of distance or texture discrimination.

Stroffregen and Pittenger (1995) call attention to the fact that “by themselves intensity differences... provide no information. This is because an echo of a given intensity could be produced by an infinite number of reflecting surfaces of different sizes, substances and distances” (p. 194). As discussed above, the difference in pulse and echo intensity is also affected by object distance and composition. Segregating the specific proportion of intensity change that can be attributed to each quality - size, distance and texture – may be difficult. The ambiguity could potentially be overcome if intensity differences are in some way cross-referenced with both delay information, disambiguating distance, and frequency spectrum information, disambiguating substance. Still, simultaneous calculation of these factors is resource intensive and subject to error which may explain subject difficulty on size detection tasks.

Motion Discrimination

A motion cue that is particularly tangible, even for the sighted, is one most people experience daily: the Doppler shift. First noted by Austrian physicist Christian Doppler in 1842, it is the net change in a perceived frequency at a specific point of observation caused by the movement of objects relative to that point. This frequency shift is caused by changes in the spacing of each successive wave front such that approaching objects produce a systematic increase in frequency while receding objects produce a decrease in frequency. The sliding ascent and descent in frequency we experience when a motorcyclist approaches and passes us is a good demonstration of this. In the case of echolocation, if an individual generates a pulse of known frequency, the velocity of an approaching or receding object can be determined based on Doppler shifting in the echo fronts. Schnitzler & Henson (1980) have studied this cue in bats, specifically *Rhinolophus ferrumequinum*, who utilize pulses fixed around 80 kHz and are capable of detecting Doppler shifts as small as 0.0375% (30Hz).

Intermodal Cuing

All the capacities discussed in this section are supplemented by information encoded by other perceptual systems other than audition. Over-dependence on a single system when navigating environments with potentially harmful obstacles is a poor strategy for survival. Thus, while a blind individual may tap with his cane to produce echolocative pulses, added tactile feedback confirms what is below his feet and what lies before him.

Intermodal cuing does not end with the sense of touch. In Ammon et al.'s (1953) outdoor echolocation experiment, it was demonstrated that individuals could detect obstacles even in complex environments replete with distractions (e.g. 30-70 dB ambient noise, traffic, construction, wind). The task involved approaching a wooden board from an unknown distance until they had perceived or collided with it. Interestingly, they reported instances in which subject performance was substantially aided by use of tactile and olfactory cuing. Wind was used in two ways:

1. When walking against the wind, subjects could detect its absence when the object acted as a wind shield.
2. When walking with the wind, subjects could detect the board by reflected air currents.

Participants used sunlight in a similar way, using the temperature decrease when the board occluded the sun and cast them into shadow and temperature increases when the light was reflected. Use of a Masonite board enabled the use of olfactory cues as well, as it gave off a distinct odour when exposed to direct sunlight. The researchers observed that these cues were used with particular frequency during the early stages of learning when participants would rely on any and every piece of information that would serve them in the task. Of course, to confirm that their results were not confounded by the use of these cues, subsequent experiments were performed. Subjects performed the same tasks at night and with nose-plugs, elimi-

nating tactile and olfactory cues, and still demonstrated excellent echolocative proficiency. Thus, these intermodal cues were supplementary but not necessary for detection.

With simple cues such as pulse-echo delay, frequency, and intensity differences a variety of conclusions about the objects in one's environment can be made. Presumably, detection of the minute temporal and intensity differences necessary for the application of these mechanisms is well within the capabilities of our auditory system. Even naïve subjects rapidly grasp tasks. The ease with which subjects acquire tasks could be taken to suggest that while humans are rarely dependent upon audition for navigation, we constantly encode and utilize these cues throughout our lives. Making associations between how a carpeted room looks and how it sounds is most likely happening all the time outside our awareness: an intriguing thought.

Where Bat Meets Man: Modern Perceptual Aids

Since the 1960s, improvements have been made in our understanding of human audition and the essential factors underlying the masterful echolocation of bats. Bridging these two bodies of knowledge, mechanical engineers have had marked success in creating perceptual aids for the blind. This section will review the essential characteristics of perceptual aids, primarily by examining the work of Dr. Leslie Kay, a distinguished researcher in the field.

Development of perceptual aids began in the 1950s. An early question was which sensory system (somatosensory or auditory) was optimal for presentation of spatial information. Tactile imaging displays use digital processes to convert optical information into an output perceived by touch. Generally this involves the use of a rectangular array of pins positioned on the user's finger with which the information is presented. The enhanced tactile sensitivity of the fingers provides the discriminatory accuracy necessary to make use of this

information. Tactile displays have proven to be very useful in reading aids (Bliss, 1970), enabling the conversion of written content into something not dissimilar to Braille. However, Bliss (1970) found that modifying this technology to work as an environmental sensor has yielded poor results. Even simple form detection and tracking tasks appear overly complex for tactile display systems.

It is not surprising, then, that the vast majority of blind mobility aids utilize auditory displays. Devices such as the Pathsounder (Russell, 1965), Mowat Sensor (Pressey, 1977) and Tri-Sensor (Kay, 2000) all use sound to encode space with surprising efficacy. The earliest aids (Cooper, 1950; Kohler, 1964; Shroger & Susskind, 1964) were designed for simple obstacle detection. Thus, they generally functioned to make users aware of imminent collisions at relatively short distances within a narrow angular range. However, given that many blind people make use of a cane or guide-dog and presumably also employ echolocative cues, simple obstacle detection devices hardly seem useful.

A more ambitious program is seen in the work of Dr. Leslie Kay, who has spent over six decades in the field (see Kay, 1946; 1966; 1974; 1976;. 1980; 2000; 2001). Unlike basic obstacle detectors, Kay's aids seek to provide highly detailed spatial representations. His approach is unique in that he believes it is best to "present to the brain the maximum amount of environmental information which the auditory sensory channel could effectively transmit" and have users learn to "disregard both redundant and unwanted information merely by switching [their] attention" (Kay, 1974, p. 608). Much like we select our points of focus in vision, a user would learn to hone in on relevant sonic features. Kay calls this process sonocular perception.

The recently-developed Trisensor (Kay, 2001), one of Kay's many devices, will provide a representative example. The Trisensor is an ultrasonic spatial sensor worn on the head. It functions by first emitting pulses of ultrasonic noise (70-140kHz) from one central and two peripheral transmitters.

The echoes produced are subsequently recorded and processed by on-board electronics. This information is converted into an audible code, which is output binaurally through headphones at frequencies within the audible human range. The information coding occurs on two dimensions:

1. Distance is coded with frequency such that as the distance of a reflecting surface increases, the frequency used to represent it increases. The frequency range spans 20 – 5000 Hz and codes objects at up to 5 metres from the unit.
2. Direction is mapped binaurally using interaural intensity difference (IID). For instance, an object located to the left of the sensor on the azimuth will be presented at a higher intensity to the left ear. This is particularly intuitive for users as IID is already a fundamental cue used in everyday auditory source localization.

Through these two features, the user can produce a mental map in which the multiple tone complexes reflect various objects in the environment (see figure 4). As subjects reorient their head, the tone complexes change in frequency and move laterally in synchrony with head movement. Intuitively, users begin to connect the tone complexes with objects existing in space.

The use of ultrasonic pulses in the Trisensor confers a distinct advantage. The extraordinary echolocators of the animal kingdom such as bats have evolved to use very high frequency pulses

(Kay, 1962). This is explained by the process of diffraction, the change that occurs in the direction of waves of energy as they pass around an obstacle. The degree to which a wave's direction is affected is directly proportional to its wavelength. Thus, high frequency waves experience the least diffraction. Waves with sufficiently small wavelengths will only be able to reflect directly back upon encountering an obstacle. Thus, the use of ultrasonic pulses in perceptual aids greatly enhances the quality of the information that is received. It

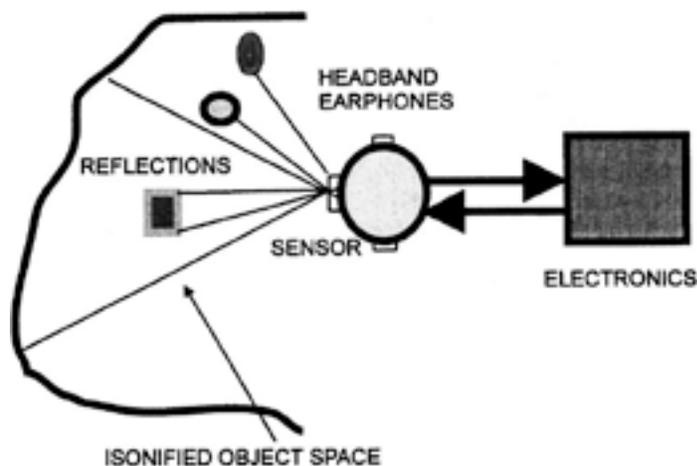


Figure 4. A schematic diagram illustrating a TriSensor user observing an 'object space' (Kay, 2001, p.804)

is important to note that using ultrasonic pulses necessitates that the echo signal be demodulated into the human audible range. This is performed through a digital process that shifts the frequency of a target wave (i.e. the echo) into a useful range. By combining the original carrier wave, f_1 , with a wave of another frequency, a new beat frequency is produced equal to the difference between the two. This new beat frequency retains the original signal of f_1 , but at a lower frequency. Through demodulation, the Trisensor can use high frequency pulses and enjoy limited diffraction while still being able to present a functional auditory output to users.

The three forehead-mounted sensors that give the device its name function in a way that is analogous with vision. The dual peripheral fields focus on the areas to the left and right of the azimuth. Acting like peripheral vision, they 1) enable detection of objects in their respective fields and 2) guide user movement through acoustic flow (similar to global optic flow) in which motion of the user relative to the acoustic environment manifests itself as a global Doppler shift (Stoffregen & Pittenger, 1995). Finally, the direction coding (based on IID) in these peripheral sensors allocates 1 dB of intensity change per angular degree. In comparison, the central field is akin to the fovea of the visual system. The central sensor allocates 2 dB of intensity change per degree which greatly improves its ability to code small spatial differences. Using these

two regions in tandem, an object initially detected in the periphery can be inspected more closely by placing it in the central field and performing a neck saccade.

The utility of Kay's devices is buttressed by both anecdotal and experimental evidence. Dr. Kay has been prolific, publishing frequently on his work. That being said, the majority of his papers do not involve any form of rigorous psychological experimentation. His tendency has been to provide his devices for no charge to a cohort of blind individuals who integrate it into their day-to-day experience. Afterwards, they provide suggestions or comments. This investigative style conforms to his primary objective: to optimize his devices and best improve the quality of life of users. His publications contain reports of such capacities as:

1. Navigating distances of 1 km by different routes including a quiet suburban area, a busy residential area and a business intersection (Kay, 1974). This included avoiding pedestrians, following sidewalks based on texture cues and crossing the street.
2. Differentiating between the sides of a USA penny through recognition of the different tone complexes associated with the "head" and the "memorial" sides (Kay, 2001).

Generally, blind participants reported feeling highly proficient within the first week using the device. Furthermore, in one cohort, 90% felt they had benefitted from their perceptual aid and 80% opted to keep their device following their week-long trial (Kay, 1974). While this evidence is subjective, it seems clear that the Trisensor is capable of conferring real benefits to blind users.

Empirical tests of these devices have also occurred. Kay (2001) conducted an experiment to quantify the minimum angular spacing between equidistant identical rods necessary for object resolution. 13 naive sighted subjects were asked to locate a target rod placed between two masking rods

at the same radial distance (see Figure 5). This arrangement is particularly difficult as each rod was equidistant and no distal pitch cue was usable. Thus, the subjects could only use IID. All subjects could resolve at 8-10° of spacing, 10 were capable at 6°, and 4 were capable at 4°. A similar experiment involving rod counting performed with blind children aged 7-11 (Hornby, Kay, Satherlay & Kay, 1985) yielded similar results. In a sensory substitution study (Strelow, Warren, Sonnier & Riesen, 1987), neonate macaque monkeys blinded at birth were raised for 1 to 3 months while continuously wearing the Trisensor. The animals demonstrated head-scanning and 'looking' with the device by the third or fourth week. For example, animals would orient the sensor's field of view to include target objects while performing reaching behaviours. When placed in novel environments, they rarely collided with obstacles. Lastly, when experimenters turned off the device, the animals were hyperactive, producing mannerisms and loud vocalizations in a display of stress. They concluded that animals reared with the device "are active, and reasonably normal, with good mobility" (p. 740).

In sum, perceptual aids such as Leslie Kay's Trisensor can be effectively used by blind and sighted subjects to navigate and engage with their environment. Bio-mimicry of the mechanisms used by nature's master echolocator, the bat, enhances existing human capacities to use sound to perceive space.

Future Directions

The study of human active echolocation is interesting in that it has been largely dormant for half a century. The majority of experiments investigating human active echolocation occurred in the 1960s, with few since. It could be presumed that this is because there is not a great deal of utility in investigating how sighted people can learn to tell different disks apart using only tongue clicks. The findings were robust enough to conclude that this capacity exists, but did not open many new avenues for research. Further study of this phenomenon, unless from a truly novel perspective,

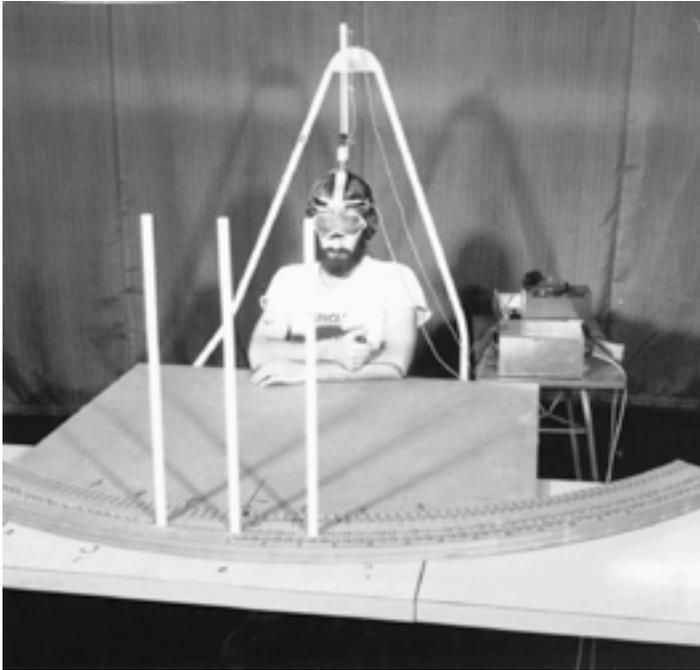


Figure 5. The apparatus use in Kay (2001, p. 804)

is unnecessary.

That being said, the continued improvement of perceptual aids is highly worthwhile. At this point, these devices are rarely used by the blind population. This is partially attributable to the difficulty in promoting them within the community (Kay, 1974). A closed system of blind mobility experts and pedagogues continue to insist use of traditional methods, namely guide-dogs and long cane navigation. Along with this exists the mistaken notion that perceptual aids are costly devices. Interestingly, a synergistic effect has been observed when using perceptual aids in addition to traditional aids such that training time for both can be reduced (Kay, 1974). If this is the case, money saved on reducing training with certified specialists could be used to offset the cost of the device. Kay's latest aid, the K-Sonar, retails at slightly over \$1000 which is less than the cost of some of the available cane training programs. In order to augment the popularity of such devices, engineers and researchers should attempt to form partnerships with blind mobility specialists. This would open up new experimental cohorts, bolstering the experimental literature and potentially clarify cer-

tain cost misconceptions.

The aids themselves should continue to be improved. Potential directions include:

1. Minimizing the degree to which the device affects users' normal perception of the auditory environment. Users should continue to be able to conduct conversations and analyze the auditory scene even with the device enabled. This can be achieved through continuing to improve earphone design to minimize the impact on natural hearing (see Morland & Mountain, 2008).
2. Reducing the size of devices while not compromising battery life.
3. Improving the field of view to include further distances and wider angles.
4. Considering inclusion of different dimensions other than distance and direction. Though it would present a substantial challenge, perhaps aspects such as colour could be represented with a code based in timbre.
5. Continuing to use animal models to test the effects of early intervention. Strelow et al.'s (1987) study with macaques found no evidence that intense exposure to the device interfered with normal development. Still, they insisted that much more research is necessary before similar trials are performed with humans.

Conclusion

In sum, it is clear that humans make use of sound when navigating their environment with or without conscious awareness. This paper has reviewed past research and suggested potential mechanisms underlying this ability. While sighted individuals can quickly learn to use echolocative cues, the population for whom active echolocation is most important is the blind. Efforts to enhance these capacities have culminated in the development of modern perceptual aids, a field with significant potential to improve the quality of life of users.

Endnotes

1. Described at length by Hayes (1935) who researched and identified fourteen independent explanations of the period ranging from the pragmatic (and correct) auditory perception hypothesis to occult and supernatural theories.
2. Teng and Whitney (2011) utilized a form of the vernier acuity task (McKee & Westheimer, 1978) adapted to the echo-perception domain to test the fine-grained limits of spatial localization.
3. Most investigators did not compare performance between those who used clicks and hisses. Rice (1967) found both signal types “sufficient to provide information on the presence or absence of an object.”(p. 660) Furthermore, when forced to switch from clicks to hisses and vice-versa, individuals demonstrated a decrement in performance. This suggests that no signal is superior and that preference is idiosyncratic. However, Arias (1997) suggested broadband hissing may provide a pulse that is superior to clicks because of its continuous nature
4. Speed of sound at 0°C is approximated at 334 m/sec (Camhi, 1984).
5. This notion is supported through an observation by Rice (1967) that certain subjects struggled to perform echo-perception tasks when their self-generated clicks were supplanted by artificial, externally generated clicks from a speaker. However, this effect was not universal within the experimental group.

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The Brain in Poverty: The Neurocognitive Correlates of Socioeconomic Status

Lisa Zhang

Introduction

According to the US Census Bureau, in 2010 15.1% of the American population lived below the poverty threshold. Furthermore, the poverty rate has increased over the last three consecutive years (DeNavas-Walt, Proctor & Smith, 2011). Given the prevalence of poverty and the link between poverty and a number of negative outcomes (Bradley & Corwyn, 2002; Brooks-Gunn & Duncan) such as various psychopathologies (Bruce, Takeuchi & Leaf, 1991; Costello et al., 1996; Offord et al., 1989), it is important that the relationship between poverty and negative outcomes is clearly characterized. Doing so will result in a better understanding of how socioeconomic status (SES) and various cognitive, physical, and social processes interact, which is the first step towards designing evidence-based interventions targeted towards improving outcomes for low income populations.

The relationship between lower socioeconomic status and more negative cognitive outcomes is well-established. Lower SES is associated with lower school achievement and lower IQ later in childhood, and in general, there is a robust relationship between lower SES and worse cognitive and academic outcomes (e.g. Bradley & Corwyn, 2002; Brooks-Gunn & Duncan, 1997;

Johnson, Dohrenwend, Link & Brook, 1999). However, more work is required on the link between SES and specific cognitive processes. A cognitive neuroscience approach is not often used in the study of poverty and SES. However, using cognitive neuroscience would allow researchers to study SES in a novel way with a new set of tools, including neuroimaging techniques. A cognitive neuroscience approach would more precisely characterize the relationship between SES and cognitive outcomes, by looking at specific neurocognitive processes rather than general cognitive outcomes.

This paper seeks to discuss neurocognitive correlates of socioeconomic status. Specifically, it will address: (1) the association between SES and specific neurocognitive systems and (2) the neurocognitive correlates of SES throughout the lifespan. Addressing these issues will clarify the association between SES and cognitive outcomes, which is the first step in the development of new interventions. This paper will review the evidence on the association between SES and particular neurocognitive systems, discuss the neurocognitive correlates of SES throughout the lifespan, consider some of the recurrent themes in the literature, and summarize overall findings.

Neurocognitive Systems and SES

Much of the work in this field has been done by Martha Farah and Kimberly Noble at the University of Pennsylvania and at Columbia University respectively. Farah, Noble, and colleagues conducted a series of studies examining the relationship between SES in childhood and neurocognitive systems using a battery of behavioural tests (Farah et al., 2006; Hackman & Farah 2009; Noble, Norman & Farah, 2005; Noble, McCandliss & Farah, 2007). The authors conceptualized five relatively independent neurocognitive systems based on the existing literature on cognitive processes and neuroanatomy: (1) the prefrontal/executive system, (2) the left perisylvian/language system, (3) the medial temporal/memory system, (4) the parietal/spatial system, and (5) the occipitotemporal/visual system. This paper will discuss the findings in the literature in terms of categories similar to those proposed by Farah and Noble.

Executive Function

Executive function is a broad term that includes many constructs such as working memory, cognitive control, reward processing, and some attentional processes (Jurado & Rosselli, 2007). Researchers have found that lower SES is associated with worse performance on executive tasks (Farah et al., 2006; Noble et al., 2005; Noble et al., 2007). Those researchers found that the association between SES and executive function was large, and the effect size of the association was the second largest of the five neurocognitive systems that were investigated. Farah et al. (2006) and Noble et al. (2007) further divided executive function into three distinct neurocognitive systems: (1) the lateral prefrontal/working memory system, (2) the anterior cingulate/cognitive control system, and (3) the ventromedial prefrontal/reward processing system. Working memory refers to the ability to hold the content or the goals of a complex task in mind. The cognitive control system is used for monitoring conflict be-

tween the individual's responses and the desired response. The reward processing system is used for dealing with rewards and punishments, and is crucial to resisting the pull of reward stimuli (Farah et al., 2006). Subjects from lower SES backgrounds have been found to perform worse than higher SES subjects on tasks assessing the lateral prefrontal/working memory system and the anterior cingulate/cognitive control system. Conversely, success on tasks assessing the ventromedial prefrontal/reward processing system was not mediated by SES (Farah et al., 2006; Noble et al., 2007).

Additional behavioural data support a SES-executive function association. Researchers found that in a low-income sample, children in the lowest wealth quintile performed worse on a working memory task compared to children from other wealth quintiles (Fernald, Weber, Galasso & Ratsifandrihamanana, 2011). There is also scientific support for SES differences in cognitive control. Another study found SES differences in performance on the A-not-B task, a test of executive function, in a sample of Argentinean infants (Lipina, Martelli, Vuelta & Colombo, 2005). In the A-not-B task, the infant is shown a desired object, and he/she is shown the object being hidden in one of two identical wells, where A is the correct well. On the subsequent trial, the infant is shown the same object again, and he/she is shown the object being hidden in the second well (the B well). Some young infants will make a perseverative error and choose A on the second trial, even though they saw the object being placed in well B. Infants of lower SES made significantly more perseverative errors compared to higher SES infants (Lipina et al., 2005). This is considered a task of inhibitory control and is associated with dorsolateral circuits in the prefrontal cortex (Lipina et al., 2005). Kishiyama, Boyce, Jimenez, Perry & Knight (2008) provided both behavioural and electrophysiological evidence in support of a general impairment in executive function in low SES children. Kishiyama found that lower SES children performed worse compared to high SES children on measures of executive function, and that low SES children,

but not high SES children, displayed a pattern of event-related potential (ERP) responses similar to patients with lateral prefrontal cortex lesions. It is important to note that Kishiyama et al. found no behavioural differences in the task used during electroencephalogram (EEG) recording, but did find a different pattern of ERP responses for low SES versus high SES children. Gianaros et al. (2011) provided fMRI evidence indicating that adults who were part of a low SES family during childhood showed reduced activation in the anterior cingulate and medial prefrontal cortices when presented with stimuli signaling reward.

Other authors have undertaken an investigation of attentional processes involved in executive function. Low SES children showed better performance on a task of executive attention (Mezzacappa, 2004). In that task, children had to disregard incongruent, distracting information in order to complete a task successfully. Low SES children showed greater decrements in accuracy and greater increases in reaction time, compared to high SES children, once the distractors were introduced (Mezzacappa, 2004). Investigation into the relationship between selective attention and SES has demonstrated an effect of SES on ERP waveform differences in response to target versus distractor stimuli. High SES children showed reduced activation in response to distractor tones, while low SES children showed equal activation for both distractor and target stimuli, suggesting that higher SES children ignore distractors while low-SES attend to both distractor and target stimuli (D'Angiulli, Herdman, Stapells & Hertzman, 2008). Stevens et al. (2009) found similar results: high SES children showed reduced amplitude responses to distractor stories compared to low SES children, suggesting that high SES children demonstrated a better ability to suppress the responses to distractor stimuli (Stevens, Lauinger & Neville, 2009). Both D'Angiulli et al. (2008) and Stevens et al. (2009) found no behavioural differences in tasks testing auditory selective attention and re-

ceptive language ability respectively. See Figure 1 (on next page) for a table summarizing studies conducted on SES and executive function.

Summary and Critique

In general, there appears to be an association between SES and executive function, with low SES individuals performing worse than high SES individuals. However, when considering the sub-systems included under the banner of executive function, the relationship between SES and executive function becomes far less defined. One of the major issues with research into executive function is that it is an incredibly broad term that includes many processes. It is hard to verify if constructs treated as relatively independent, relatively localized systems (e.g. the lateral prefrontal/working memory system and the anterior cingulate/cognitive control system) exist in reality, and it is also difficult to determine what specific processes are involved in each system. Another challenge is determining whether a given task is accurately measuring the processes it is intended to measure. Kishiyama et al.'s (2008) battery of neurocognitive tests included the Trail Making Test (TST) and the Stroop Color and Word Test, which are considered tests of set shifting and inhibitory control. In that study, the researchers found a high SES advantage for the Trail Making Test, but no significant SES differences for the Stroop Color and Word Test. The authors concluded that low SES individuals perform worse on tests of executive function without addressing test-level differences. It is necessary to know in precisely what ways tasks that produce different results differ from each other, in order to make a persuasive argument about the associations between SES and specific systems. Various studies provide contradictory data regarding the relationship between SES and specific executive function processes. For example, Gianaros et al. (2011) found that low SES adults showed reduced fMRI blood oxygen level dependence (BOLD) values in the anterior cingulate cortex and the dorsomedial prefrontal cortex during the presentation of stimuli signaling reward. Conversely, other researchers found

Study	Sample size	Age	Type of data	Finding
Noble et al., 2005	60	Kindergarteners	Behavioural	Low SES performed worse
Farah et al., 2006	60	10- to 13-year-olds	Behavioural	Low SES performed worse on lateral prefrontal/working memory (significant); Low SES performed worse on anterior cingulate/cognitive control (approaching significance); no SES differences for ventromedial prefrontal/reward processing
Noble et al., 2007	150	First grade children	Behavioural	Low SES performed worse on lateral prefrontal/working memory (significant); Low SES performed worse on anterior cingulate/cognitive control (significant); no SES differences for ventromedial prefrontal/reward processing
Mezzacappa, 2004	249	6-year-olds	Behavioural	Low SES showed greater performance decrements when a incongruent information was presented
Kishiyama et al., 2008	28	7- to 12-year-olds	Behavioural, ERP	No behavioural differences on ERP task (everyone at ceiling); Low SES children displayed ERP responses similar to patients with lateral PFC lesions; separate battery of neurocognitive tests found low SES performed worse on EF tasks
Fernald et al., 2011	1332	3- to 6-year-olds	Behavioural	Low SES performed worse on working memory task
Gianaros et al., 2011	76	31- to 54-year-olds	fMRI	Low childhood SES group showed reduced activation in anterior cingulate and medial prefrontal when presented stimuli signaling reward
Lipina et al., 2005	280	6-14 month old children	Behavioural	Low SES performed worse on A-not-B task, an executive function task related to working memory and is associated with lateral PFC
D'Angiulli et al., 2008	28	Grade 6 to grade 9 children	Behavioural, ERP	No SES differences in the behavioural task; ERP waveform differences between attended and unattended tones were significant in high SES but not low SES
Stevens et al., 2009	32	3- to 8-year-olds	Behavioural, ERP	No SES differences in the behavioural task; Low SES had higher-amplitude response to probes in the distractor condition

Figure 1: Summary of executive system research

no behavioural differences in tasks assessing the ventromedial prefrontal/reward processing system (Farah et al., 2006; Noble, Wolmetz, Ochs, Farah & McCandliss, 2006). There are a few possible interpretations of these results. It is possible that the two sets of studies measured different reward-related processes. Alternatively, SES differences may exist only in childhood (Farah et al., 2006; Noble et al.,

2006), and those differences may not persist into adulthood (Gianaros et al., 2011). Finally, it is possible that reward processing may involve neural differences that do not manifest as behavioural differences. This last is the most probable interpretation based on the extant research. The discovery of neural, but not behavioural differences has been found many times in the literature describing the relationship between

SES and executive function (e.g. D'Angiulli et al., 2008; Kisiyama et al., 2008; Stevens et al., 2009, above) The A-not-B task used in Lipina et al.'s 2005 study is associated with the lateral prefrontal cortex, which suggests that it successfully engages working memory. However, it is unclear to what extent the task is a working memory task. Although the A-not-B task requires that the infant hold information in memory in order to accomplish the task, it also appears to be a measure of inhibition and control (i.e. infants have to inhibit their behaviour, and forgo choosing well A), which appears more similar to the construct of cognitive control. Indeed, evidence has been provided that indicates that inhibition tasks that appear to depend on lateral prefrontal or anterior cingulate regions may actually depend on the inferior frontal cortex (Aron, Robbins & Poldrack, 2004). Consistency in the use of tasks and constructs is, for the most part, missing from the literature, which is problematic when relating SES and specific executive processes.

Furthermore, it is unclear to what extent the selective attention tested by D'Angiulli et al. (2008) and Stevens et al. (2009) is related to other studies of SES and attention. The tasks that were used involved attending to pertinent information rather than to distractor information. Mezzacappa et al. (2004) employed a similar task, where subjects had to attend to a particular stimuli while ignoring incongruent (distractor) stimuli. Mezzacappa and colleagues identified their task as one assessing executive attention, which refers to top-down, volitional control of attention resources (Posner & Rothbart, 1998). It is unclear if Mezzacappa's task, and D'Angiulli's and Stevens' tasks pertain to the same construct. It is also ambiguous how these studies of attention relate to Farah and Noble's executive function classification system (Farah et al., 2006; Noble et al., 2007). According to some researchers, selective attention is actually a component of cognitive control, since both processes require that an individual must selectively use a certain process or com-

plete a certain action to promote task-appropriate responding (Miller & Cohen, 2001). This line of thinking would suggest that cognitive control, selective attention, and executive attention may all be highly related – perhaps even part of a single neurocognitive system. At this point, however, the abundance of disparate terms and tasks used in the executive function and SES literature makes it difficult to say with certainty how SES is related to the specific processes that fall under executive function. Further research where tasks and constructs are clearly and consistently defined is necessary for a more conclusive statement about the relationship between SES and attention.

It is also important to note that, with the exception of Gianaros et al.'s 2011 study, all the studies reviewed on in the area of executive function used children as subjects. In order to understand if the relationship between SES and executive function generalizes to other age groups, it is necessary to conduct research on SES and executive function in both infant and adult populations.

The Language System

Researchers have found evidence for an association between left perisylvian/language system score and SES, with lower SES children performing significantly worse on tasks assessing left perisylvian/language processes when compared to higher SES children (Farah et al., 2006; Noble et al., 2005; Noble et al. 2007). In fact, the association between the left perisylvian/language system and SES was larger than the association between any other neurocognitive systems and SES (Farah et al., 2006; Noble et al., 2005; Noble et al., 2007). Researchers have reported that SES accounted for about 30% of the variance in scores for left perisylvian/language tasks (Noble et al., 2005; Noble et al., 2007).

The remainder of the current research investigating the relationship between left perisylvian/language ability and SES does not investigate the relationship as explicitly as Noble, Farah, and col

leagues (Farah et al., 2006; Noble et al., 2005; Noble et al., 2007). Instead, the remainder of the research in the field has focused on specific language related abilities. Although it is not clear if the constructs being tested are left perisylvian system-mediated language processes, all of the remaining studies examine language-related processes. The research discussed thus far has relied on behavioural data. Some of the subsequent literature that will be discussed used neuroimaging and electrophysiological data to further elucidate the relationship between SES, the brain, and language.

Kishiyama et al. (2008) found behavioural differences in language ability between lower SES and higher SES children. Low SES children performed significantly worse on the vocabulary subtest of the Wechsler Intelligence Scale for Children (WISC-III) when compared to their high SES counterparts. In an effort to investigate SES differences in the context of extreme poverty, Fernald and colleagues (2011) catalogued SES differences in cognitive ability in Madagascar, a low-income country with a gross national income per capita of 340 USD and 68% of its inhabitants living below the poverty threshold as defined by international standards (Fernald et al., 2011). The greatest SES differences were found in receptive language, or language abilities related to comprehension, with the top wealth quintile of the sample scoring on average .72 standard deviations greater than the lowest wealth quintile (Fernald et al., 2011)

Researchers have also conducted studies based on imaging and electrophysiological data. Noble et al. (2006) investigated the relationship between SES, phonological awareness, and brain activity as measured by functional magnetic resonance imaging (fMRI). The authors defined phonological awareness (PA) as an ability to explicitly represent and manipulate the sounds of language; this ability strongly predicts reading achievement. The study found that the correlation between PA ability and left fusiform and perisylvian region activation decreased with increasing SES. That is, high SES children with low

PA ability showed greater activation in left fusiform and perisylvian regions as compared to low PA ability with low SES children during a reading task. Noble and colleagues hypothesized that higher SES afforded increased exposure to reading experiences, and that this may have had a protective effect in terms of reading ability. In the presence of low perisylvian ability, higher SES children may have learned to recruit left fusiform and perisylvian regions to a greater extent, which may have led to increased reading achievement. In fact, this study found that amongst low PA ability children, high SES children displayed relatively high reading achievement while low SES children showed relatively low reading achievement. However, the researchers also found evidence for the same relationship, but in the opposite direction, for other brain areas involved in PA; the evidence indicated a greater correlation between right perisylvian activity and PA ability in high SES children, which is directly opposite to the results found for the left perisylvian area (Noble et al., 2006).

Other researchers have also found brain-related differences associated with reading in young children. Raizada, Richards, Meltzoff, and Kuhl (2008) found a significant correlation between SES and the degree of hemispheric specialization in the left inferior frontal gyrus (IFG). Low SES children showed less hemispheric specialization in the left IFG. In addition, low SES children showed smaller grey and white matter volumes in the left IFG. These findings remained significant even after controlling for scores on standardized language and cognition tests, indicating that hemispheric specialization and grey and white matter volume of the IFG showed differences beyond those predicted by performance on language and cognition tests. Furthermore, there was no correlation between behavioural performance on the rhyming task that was used in the scanner and IFG asymmetry, providing further evidence that IFG asymmetry differences were greater than what would be predicted by behavioural data (Raizada et al., 2008). These brain

Study	Sample size	Age	Type of data	Finding
Noble et al., 2005	60	Kindergartners	Behavioural	Low SES performed worse; strong association
Farah et al., 2006	60	10- to 13-year-olds	Behavioural	Low SES performed worse; strong association
Noble et al., 2007	150	First grade children	Behavioural	Low SES performed worse; strong association
Noble et al., 2006	38	First to third grade children	Behavioural, fMRI	Low SES showed stronger positive association between phonological ability and fusiform activity; i.e. high SES children with low phonological ability recruit fusiform gyrus more
Kishiyama et al., 2008	28	7- to 12-year-olds	Behavioural	Low SES showed worse performance on vocabulary
Raizada et al., 2008	14	5-year-olds	Behavioural, fMRI	No SES differences in the behavioural task; Low SES showed less hemispheric specialization of the left inferior frontal gyrus; Low SES had smaller grey and white matter volumes in the inferior frontal gyrus
Fernald et al., 2011	1332	3- to 6-year-olds	Behavioural	Low SES performed worse on receptive language task, $d=.72$ (also other SES differences, but the difference was greatest for language)

Figure 2. Summary of language system research

differences in the left IFG, which is part of the perisylvian neural system (Catani, Jones & Ffytche, 2005) supports the existence of SES differences in the perisylvian/language system. See Figure 2 for a table summarizing the SES/language literature.

Summary and Critique

There is robust evidence supporting a relationship between SES and the language system. Noble et al. (2005), Farah et al. (2006), Noble et al. (2007), Kishiyama et al. (2008), and Fernald et al. (2011) found behavioural evidence indicating that lower SES children perform worse than higher SES children on language-related tasks.

In terms of SES differences in specific abilities, there is strong support for a higher SES advantage in vocabulary with convergent findings from several studies (Farah et al., 2006; Fernald et al., 2011; Kishiyama et al., 2008; Noble et al., 2006). There is mixed evidence, however, for the nature of SES differences in language-related brain activity. Although both Noble et al. (2007) and

Raizada et al. (2008) found SES differences in perisylvian regions of the brain, they reported contradictory evidence. Noble et al.'s (2006) main finding was that high SES children showed less correlation between phonological awareness (PA) ability and left perisylvian activity. This suggests that high SES children with low PA ability recruited the left perisylvian to a greater extent than low SES children, whose PA scores were reflected in their left perisylvian activity. However, the opposite result was found in another brain area; high SES children showed greater positive correlation between PA ability and right perisylvian activity, another brain area correlated with PA ability (Noble et al., 2006). The authors failed to explain these results. Furthermore, it is unclear precisely how Noble et al.'s results relate to the findings of Raizada et al. (2008), who found increased asymmetry favouring the left hemisphere in high SES children. This evidence is consistent with the hypothesis that high SES children showed greater recruitment of the left hemisphere during

A)

Study	Sample size	Age	Type of data	Finding
Noble et al., 2005	60	Kindergarteners	Behavioural	No SES differences
Farah et al., 2006	60	10 to 13-year-olds	Behavioural	Low SES performed worse
Noble et al., 2007	150	First grade children	Behavioural	Low SES performed worse

B)

Study	Sample size	Age	Type of data	Finding
Noble et al., 2005	60	Kindergarteners	Behavioural	Non-significant trend; Low SES performed worse
Farah et al., 2006	60	10 to 13-year-olds	Behavioural	Non-significant trend; Low SES performed worse
Noble et al., 2007	150	First grade children	Behavioural	Low SES performed worse

C)

Study	Sample size	Age	Type of data	Finding
Noble et al., 2005	60	Kindergarteners	Behavioural	Non-significant trend; Low SES performed worse
Farah et al., 2006	60	10 to 13-year-olds	Behavioural	Non-significant trend; Low SES performed worse
Noble et al., 2007	150	First grade children	Behavioural	Low SES performed worse

Figure 3. A) Summary of memory system research B) Summary of spatial system research C) Summary of visual system research

reading; however, it is unclear what specific mechanisms are at work. It may be that higher SES individuals show increased recruitment of the left hemisphere; however, given the higher correlation between high SES and right perisylvian activation, one might then conclude that low SES individuals conversely show increased recruitment of the right hemisphere. It is unclear how these results might relate to a high SES advantage in language ability. It is necessary to conduct further imaging studies to clarify what brain mechanisms are involved in language ability.

All the studies reviewed above investigated SES-language associations in children only. It is unknown whether those relationships exist in infancy (which provide support for more of a genetic, rather than environmental theory of SES-language association) and whether those relationships continue into adulthood. These questions should be

researched further.

Memory, Spatial, and Visual Systems

Compared to research on the relationship between SES and language and executive function, there is far less literature on memory, spatial, and visual systems. For this reason, a review of the literature on these three topics has been collapsed into one section. Initially, no relationship was found between the medial temporal system/memory and SES (Noble et al., 2005). Later studies used a more difficult version of the memory task used in Noble et al.'s 2005 study, with a longer delay. These studies found that lower SES children performed worse than higher SES children on memory tasks designed to assess memory associated with the medial temporal system (Farah et al., 2006; Noble et al., 2005; Noble et al., 2007). Non-significant SES differences favouring high SES children were found in the realms

Study	Sample size	Age	Type of data	Finding
Turrell et al., 2002	486	58-64	Behavioural	Cumulative exposure to low SES associated with worse cognitive function
Singh-Manoux et al., 2005	7830	46-68	Behavioural	Childhood low SES led to worse cognitive function in childhood through its influence on adult SES
Gianaros et al., 2011	76	31- to 54-year-olds	fMRI	Low childhood SES group showed reduced activation in anterior cingulate and medial prefrontal when presented stimuli signaling reward in adulthood
Otero et al., 1994	42	18-30 months	EEG	Low SES showed EEG results suggesting a maturational lag
Otero et al., 1997	42	4-year-olds	EEG	Low SES showed EEG results suggesting a maturational lag

Figure 4. Summary of the research on neurocognitive correlates of SES throughout the lifespan

of spatial and visual processes (Noble et al., 2005; Farah et al., 2006). A third study with a larger sample size and a more powerful design using a continuous, rather than dichotomous, measure of SES found that lower SES children performed worse on both spatial and visual tasks when compared to higher SES children (Noble et al., 2007). See Figure 3 for a summary of the results.

Summary and Critique

Few studies have been conducted on SES and memory, spatial, and visual systems. The general consensus of these few studies is that SES differences likely exist in these systems, but that these differences are small, especially compared to SES-related differences found in the domains of executive function and language. Further research needs to be conducted (1) to determine if consistent SES differences in memory, spatial, and visual systems exist and what the effect sizes of any differences may be and (2) to more precisely characterize the relationship between SES and these neurocognitive systems. There may, for example, be more complex modulatory effects of SES on these abilities. Though not a direct relationship between SES and neurocognitive processes, researchers have found that SES may modify sex differences in spatial skill (Levine et al., 2005). Furthermore, all results obtained for memory, spatial, and visual systems involved child subjects.

More research with different age groups is necessary in order to determine if the results found for children generalize to other age groups. As the literature currently stands, there is insufficient data to make decisive statements about the relationships between SES and the memory, spatial, and visual systems.

Neurocognitive Correlates of SES Throughout the Lifespan

All of the research reviewed thus far have used cross-sectional designs and involved child subjects, with the exception of the adult sample used in Gianaros et al.'s 2011 study. The relationship between SES and neurocognitive processes is less clear when considering how the relationship changes over the lifespan. This paper will discuss a number of studies focusing on the neurocognitive correlates of SES throughout the lifespan. A number of researchers have begun addressing this topic. Turrell et al. (2002) examined the influence of childhood and adult socioeconomic position on cognitive function in late middle age. The researchers found that both childhood SES assessed retrospectively and adulthood SES were associated with worse performance on a battery of cognitive tests. Furthermore, cumulative exposure to low SES was found to be associated with worse cognitive function (Turrell et al., 2002). Other researchers have found

that low childhood SES led to worse cognitive function in adulthood through its influence on adult SES (Singh-Manoux, Richards & Marmot, 2005). It has also been shown that low childhood SES is associated with reduced activation in the anterior cingulate and medial prefrontal cortex when presented with stimuli signaling reward in adulthood, even after controlling for adult SES, which suggests that adults who came from a low SES environment may show differences in reward processing and corticostriatal activation (Gianaros et al., 2011). Other researchers have found that low SES children show a pattern of EEG activation suggesting a maturational lag in neural development starting in infancy and persisting into early childhood (Otero, 1994; Otero, 1997). See Figure 4 for a summary of results of research in this area.

Summary and Critique

There is data to support the assertion that both childhood and adult SES influence later cognitive function (Gianaros et al., 2011; Singh-Manoux et al., 2005; Turrell et al., 2002) and that the combined influence of low SES in childhood and adulthood is associated with worse cognitive outcomes than low SES at only one point in life (Turrell et al., 2002). However, there is some contradictory evidence regarding the specifics of these relationships. Turrell et al. (2002) found that low childhood SES was directly linked to worse cognitive outcomes in adulthood while Singh-Manoux et al. (2005) found no direct relationships between childhood SES and cognitive outcomes, though they did find indirect effects of childhood SES. Gianaros et al. (2011) found that low childhood SES was linked to a differential pattern of neural activation, but found no behavioural differences in terms of task performance when comparing low childhood SES individuals with high childhood SES individuals. Therefore, it appears that extant research supports two contradictory interpretations. The data supports a direct effect childhood SES on later behavioural measures of cognitive outcomes (Turrell et al., 2002), but other data suggest that childhood SES does not directly impact adult, behavioural measures of cognitive function (Gianaros et al.,

2011; Singh-Manoux et al., 2005). The Singh-Manoux study used subjects from the Whitehall II study, which followed a cohort of white collar British civil servants over time (Marmot et al., 1991). Given the limited sample of the Singh-Manoux study, it is likely that a relatively narrow range of SES's was sampled, and it is possible the design of the study was not powerful enough to pick up independent effects of childhood SES on behavioural measures of cognitive function. Further work should be done to clarify whether childhood SES directly impacts later cognitive function. Another area of future research would be to investigate to what extent childhood SES impacts adult neural processes, given the scarcity of research regarding this question. The Gianaros et al. (2011) study was the only experiment reviewed that looked at neural processes in this way, and that study only investigated very specific neural processes related to reward processing.

Furthermore, it should be noted that all of studies in this area depended on retroactive recall of childhood SES rather than a longitudinal assessment of SES in both childhood and adulthood. For example, while the 2005 Singh-Manoux study used a longitudinal cohort from the Whitehall II study, the study itself was not longitudinal and, like Turrell et al.'s study, relied on retroactive recall of childhood SES. Using retroactive recall of childhood SES comes with limitations; it is difficult to verify the accuracy and completeness of the data. In order to make strong causal statements regarding the relationship of childhood SES and adult cognitive outcomes, future research should be conducted using a longitudinal design where SES and cognitive function are evaluated in both childhood and adulthood.

Issues in the Literature

Research investigating SES and its neurocognitive correlates is still in its infancy. Certain themes and recurrent issues emerge from the entire body of research on the neurocognitive correlates of SES. As a whole, there is evidence of a relationship between SES and broad categories of

neurocognitive processes; however, finer associations between SES and more specific neurocognitive processes are not well understood. Further work should be conducted in order to make these finer associations. Researchers should attempt to integrate information about the relationship between SES and various neurocognitive processes and use that information to create consistent definitions of constructs and to come to an agreement on which tasks should be used to measure each construct.

Additionally, it is necessary to conduct further research with more diverse sample populations. The majority of the work done thus far has used child subjects. Further research is needed in order to more clearly characterize the relationship between SES and neuro-cognitive processes throughout the entire lifespan.

Another crucial problem with the literature is an over-dependence on cross-sectional designs. With the exception of the two Otero et al. studies, which reported data from a single cohort at two time points, (Otero et al., 1994; Otero et al., 1997) all the studies reviewed in this paper have used cross-sectional designs. Although cross-sectional designs allow researchers to undertake preliminary work in order to establish the existence of associations between SES and various neurocognitive processes, this design limits the ability of researchers to make causal conclusions. Further work is required using longitudinal methodologies, and study designs that give researchers more power to make causal references. For example, although some researchers make hypotheses about the mechanisms that mediate the relationship between SES and neurocognitive processes, little or no empirical work has been done investigating these mediators. Hackman and colleagues suggest toxin exposure, nutrition, prenatal drug exposure, stress, differential cognitive stimulation, and parenting styles as potential candidates as mediators of the relationship between SES and neurocognitive processes (Hackman & Farah, 2009; Hackman, Farah & Meaney, 2010). Research should be conducted to empiri-

cally test these candidate mediators. It would also be interesting to investigate the relative contributions of genetics and environment to SES differences in neurocognitive processes. Although work in this area has begun (e.g. Chiang et al., 2011), to the author of this paper's knowledge, no study has explicitly looked at genetic versus environmental contributions to the neurocognitive correlates of SES.

Finally a caveat: although cognitive neuroscience allows researchers to use a whole new set of tools to more precisely characterize the relationship between SES and neurocognitive systems, it is important to be careful when making conclusions based on imaging data. Imaging data is notoriously ambiguous; for example, a greater fMRI BOLD signal is correlated with brain activity, but neuroimaging results are not necessarily directly indicative of actual brain activity. Researchers conducting research with fMRI and EEG should beware of making bold claims based on neuroimaging data and acknowledge the limitations of neuroimaging techniques.

Conclusion

There is a robust link between SES and language and executive function, and this link is supported by both behavioural and neural evidence. Researchers have also found some evidence for a link between SES and memory, spatial processes, and visual processes, although this association appears to be smaller in magnitude than the association between SES and language or executive function. Evidence also exists supporting the notion that both childhood and adult SES influence adult cognitive function, though whether these effects are direct or indirect is still up for debate. One recurrent theme in the research is the presence of neural differences as measured by fMRI, MRI, and EEG in the absence of behavioural differences. This suggests that, depending on SES, different types of mental

processes may underlie the same behavioural processes. This is a tantalizing idea and pursuing it may allow researchers to better understand the relationship between SES and behavioural outcomes.

In general, further evidence is necessary in order to make strong, causal conclusions about SES and its neurocognitive correlates. Most of the research to date has focused on characterizing the relationship between SES and neurocognitive processes. Once these relationships are better understood, that understanding may lead to new intervention designs. In fact, some preliminary research on intervention designed to target specific neurocognitive systems has begun. For example, the Tools of the Mind curriculum specifically targets executive function (inhibitory control, working memory, and cognitive flexibility), and it has been shown to improve executive function in preschoolers in regular classrooms with regular teachers at minimal expense in children of low-income families (Diamond, Barnett, Thomas & Munro, 2007). Once a full complement of descriptive data is obtained regarding the relationship between SES and neurocognitive processes, researchers can further consider the applications of the research in terms of interventions and policy. The study of SES differences and neurocognitive differences has already revealed much about how SES is related to a series of cognitive processes, and may continue to yield important results.

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