The Relationship between Positive Schizotypy and Apophenia in Pattern Recognition

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Abstract

Background: Positive schizotypy is a construct comprised of a subset of symptoms belonging to the broader concept of schizotypy in general. Many of these symptoms are believed to overlap with apophenia, which is the tendency to perceive patterns in the world where none exist, or to commit type 1 errors in the attribution of meaning to information. The relationship between these two concepts with respect to pattern recognition arguably remains unclear. **Purpose:** The purpose of this study was to investigate how positive schizotypy and apophenia are associated with type 1 error pattern detection. We predicted that individuals who scored higher on measures of positive schizotypy and apophenia would report perceiving more patterns and meaning than individuals that scored lower on these measures. We also explored whether apophenia would mediate the relationship between positive schizotypy and task performance. **Method:** Participants comprised 96 college students. A computer stimulus involving multiple images of random displays of dots (RDT task) was used to assess this tendency of perceiving patterns and meaning where none in fact are present. Self-report measures were given to assess positive schizotypy and apophenia. **Results:** As predicted, individuals that scored higher on measures of positive schizotypy also scored higher on measures of apophenia and reported perceiving more meaningful patterns during the experimental task. Apophenia did not mediate this relationship between positive schizotypy and task performance. **Conclusions:** Individuals exhibiting higher levels of positive schizotypy may be more prone to perceiving patterns and meaning in sense data where none in fact exist than individuals exhibiting lower levels of the construct. This relationship does not appear to be better explained by the concept of apophenia. Future research and the implications of the relationship between positive schizotypy, pattern detection, and related concepts are discussed.

Keywords

Schizotypy, Apophenia, Pattern Recognition, Personality

1. Introduction

Schizotypy has been considered both a predisposition for and a susceptibility to schizophrenia spectrum disorders (SSD's), as well as being a manifestation of subclinical levels of schizophrenia-related symptomatology (Kwapil & Barrantes-Vidal, 2015). There are two main models of schizotypy that have been posited: a quasi-dimensional model and a fully-dimensional model (Farias, Claridge, & Lalljee, 2005). The quasi-dimensional model posits that schizotypy and normality are discontinuous, and places it along a spectrum whereas at some point the symptom becomes pathological (Farias, Claridge, & Lalljee, 2005). The fully dimensional model posits that psychotic traits represent natural personality variations, and do not necessarily inevitably result in pathology (Farias, Claridge, & Lalljee, 2005); this latter model is the conceptualization of schizotypy that is adopted for this study and is most supported by current research. Factor analytic research on the nature of schizotypy has resulted in varying multifactorial models, some yielding three dimensional factors, and others yielding four (Mason, Claridge, & Jackson, 1995; Raine, Reynolds, Lencz, Scerbo, Triphon, & Kim, 1994). More recent research has argued for the presence of three, as opposed to four, main factors in schizotypy: 1) positive schizotypy; 2) negative schizotypy; and 3) disorganized schizotypy (Kwapil & Barrantes-Vidal, 2015; Kwapil, Gross, Burgin, Raulin, Silvia, & Barrantes-Vidal, 2018).

One of the most common and well validated factors that has been extracted from these factor analyses is positive schizotypy (Carson, Peterson, & Higgins, 2003; DeYoung, Grazioplene, & Peterson, 2012; Kwapil & Barrantes-Vidal, 2015). There are a number of behavioral and cognitive characteristics that have been said to be constituents of positive schizotypy; these include the presence of unusual experiences, covariance pattern detection, propensity toward type 1 errors, aberrant perceptions, ideas, and salience, magical ideation, and overinclusive thinking (DeYoung, Grazioplene, & Peterson, 2012; DeYoung, 2013; Eckblad & Chapman, 1983; Fink, Weber, Koschutnig, Benedek, Reishofer, Ebner, Papousek, & Weiss, 2014; Fyfe, Williams, Mason, & Pickup, 2008; Holt, Simmonds-Moore, & Moore, 2008; Nelson & Rawlings, 2010). The concept that arguably underlies much of what positive schizotypy is thought to involve is called apophenia (DeYoung, Grazioplene, & Peterson, 2012). Apophenia describes the tendency to perceive meaningful patterns and causal connections where none in fact exist (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020; DeYoung, Grazioplene, & Peterson, 2012; Mishara, 2010; Partos, Cropper, & Rawlings, 2016). Some researchers have even gone as far as using the term somewhat interchangeably with positive schizotypy, as much of the research assessing the construct has done so using self-report measures of positive symptoms indicative of schizotypy (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020; DeYoung, Grazioplene, & Peterson, 2012). The concept characterizes the general human evolved propensity for committing false positives, or type 1 errors (identifying a pattern as meaningful when the observation is due to chance) (DeYoung, Grazioplene, & Peterson, 2012). It has also been described

as believing in the objectivity of patterns without sufficient evidence (DeYoung, Grazioplene, & Peterson, 2012). This tendency in apophenia, as well as positive schizotypy in general, to be hypersensitive to the detection of covariance patterns has been said to potentially result in overinterpretations of coincidences and sensory noise, and thus to consider them as meaningful patterns (DeYoung, Grazioplene, & Peterson, 2012). Magical Ideation, a constituent of positive schizotypy, is positively correlated with identification of meaningful patterns in noisy or random visual stimuli (DeYoung, Grazioplene, & Peterson, 2012), as well as with apophenia (Kaufman, 2012). Apophenia is not a tendency that is solely observed in the context of psychopathology and can and does occur in the normal population, which allows this construct t to be studied in non-clinical populations (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020).

Positive schizotypy and apophenia are two concepts that appear to share similar characteristics regarding aberrant salience (DeYoung, Grazioplene, & Peterson, 2012). Given these seemingly qualitative similarities observed in the literature, the specifics of the relationship between the two are a topic of current investigation, specifically regarding salience misattribution and erroneous pattern recognition (DeYoung, Grazioplene, & Peterson, 2012). This study attempts to investigate the relationship between positive schizotypy and apophenia, and the aberrant salience that appears to be endemic to each construct. The study attempted to understand how symptoms of positive schizotypy and apophenia impacted the tendency to observe patterns in random stimuli sets using an experimental stimulus detection task. The presence of a tendency to detect meaningful patterns in random stimuli reflects a core feature of the condition, and there have been previous empirical studies examining features of these relationships using different methodologies, designs, and measurements (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020; Brugger & Graves, 1997; Fyfe, Williams, Mason, & Pickup, 2008; Galdos et al., 2011; Grant, Balser, Munk, Linder, & Hennig, 2014). We hypothesized that 1) on average, individuals higher in positive schizotypy would report higher levels of apophenia, more meaning and pattern detection, and thus less accuracy in the experimental task (greater type 1 error frequency) than would individuals lower in positive schizotypy, and that 2) this relationship between positive schizotypy and task performance (greater type 1 error frequency) would be mediated by apophenia.

2. Methods

2.1. Participants

Participants were 96 undergraduate students currently attending the University of Texas at Tyler and were enrolled in 1000 and 2000 level psychology courses. Institutional review board approval from the University of Texas at Tyler was obtained prior to data collection. Participants were recruited using SONA System, which is the University of Texas at Tyler research participation and sign-up system. There were 25 males and 71 females in the sample, and there were significantly more females in the sample compared to males, $X^2 = 22.04$ ($df = 1, 95$),

p < .05. This gender disparity was not consequential for any measurement variables. There were also significant differences in terms of ethnicity (more Caucasian participants) in the sample, X^2 = 74.73 (*df* = 5, 91), *p* = .05, but like gender, this was not consequential for any variables of interest. Data on participant demographics are presented in Table 1. There were no exclusion criteria for participant recruitment.

2.2. Measures

The Aberrant Salience Inventory (ASI) was used to measure apophenia (Cicero, Kerns, & McCarthy, 2010). The ASI is a 29-item scale that is answered in a yes/no format to provide a measure of aberrant salience (unusual or erroneous assignment of salience, meaning, and/or significance to internal or external stimuli) and psychosis proneness in nonclinical samples (Cicero, Kerns, & McCarthy, 2010). These two concepts of apophenia and aberrant salience have near synonymous features, and have been described as mostly simpatico (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020). Totals were calculated and were used as the variable of interest (ranged from 0 - 29); higher scores reflected higher levels of apophenia. The ASI has been shown to have good psychometric reliability and validity (Cicero, Kerns, & McCarthy, 2010). For the current sample, the internal consistency of the measure was very good, *Cronbach's a* = .825.

The Magical Ideation Scale (MIS) was used to measure positive schizotypy (Eckblad & Chapman, 1983). This scale contained 30-items answered in a true or false format. The scale has been shown to be one of the most valid measures of positive schizotypy, as well as predictive of psychotic symptom development in at-risk populations (Eckblad & Chapman, 1983). The total score on the Magical Ideation scale was calculated and ranged from 0 to 30 (Eckblad & Chapman, 1983); higher scores reflect higher levels of magical ideation. For the current sample, the scales' internal consistency was very good, *Cronbach's a* = .883.

The dependent measure/variable in this study was an experimental task involving the assessment of pattern recognition and meaning detection, namely, the Random Dots Display Task (RDT) (Jakes & Hemsley, 1986; Partos, Cropper, & Rawlings, 2016). The procedure and scoring criteria for the Random Dots Display Task followed the work of Jakes & Hemsley (1986), and Partos, Cropper, & Rawlings (2016). During the task, participants were seated in front of a computer monitor and told that they would be shown changing patterns of white dots on a black background, some patterns being random, and others being designed to consist of something meaningful. In actuality, no patterns were designed to consist of anything meaningful, and all were random. Because the sample was not qualitatively clinical in nature, maximizing the opportunity space to commit false positives was attempted in this way; that is, in using a task wherein *all* responses were type 1 errors. Participants were then told to report out loud if or when they see something meaningful or recognizable, and to describe what they see. Their responses were recorded verbatim by the researchers,

Table 1. Summary of participant demographics.

Variable	Participants Mean (SD)
N	96
Age (Years)	21.56 (6.85)
Education (Years)	12.75 (1.37)
% Male	26%
% Caucasian	54.20%

who were seated at a distance behind the participant (Partos, Cropper, & Rawlings, 2016). The Random Dots Display stimuli were presented using *MATLAB* (2010) software and were the same as those used by Partos, Cropper, & Rawlings (2016), namely, 60 random arrays of 400 dots (Partos, Cropper, & Rawlings, 2016). Responses to the stimuli were recorded and summed, with scores on this task being the total number of responses (Jakes & Hemsley, 1986; Partos, Cropper, & Rawlings, 2016).

2.3. Procedures

All participants signed up for the study using SONA systems and received extra credit for their participation. The study was conducted in a face-to-face format in the Psychotic Disorders Research Laboratory located at the University of Texas at Tyler. Once at the lab, informed consent was obtained from the participants, and the self-report measures were administered by the principal investigator; completion of the self-report scales, in the vast majority of cases, took between one and two hours.

After the self-report measures were completed, the participants underwent the experimental task, the Random Dots Display (Jakes & Hemsley, 1986; Partos, Cropper, & Rawlings, 2016; Ruiz et al., 2005) which was administered on a computer. Completion of the Dots task in the large majority of cases took approximately between one and two hours to complete. The participants recruited via the SONA system were compensated with extra credit in one or more of their classes that they were enrolled in at the time.

3. Results

Prior to running the primary analyses, we conducted a series of preliminary analyses to examine the statistical properties of the data (means, standard deviations, normality, etc.) (see Table 2 and Table 3 for variable summary statistics and bivariate correlations, respectively). Two findings from these initial analyses warranted additional and more thorough data analyses prior to formal hypothesis testing, namely, the obtained sample size of the study, and the failure of one or more variables to meet the necessary criteria of parametric assumptions. Depending on the variable(s) and the desired analysis, some parametric assumptions were met, but it was rare for all of them to be satisfied ubiquitously. Because of these data qualities, additional supplemental variable transformations

were conducted to ensure a complete understanding of the data. After running these initial analyses, others were conducted using SPSS and PROCESS MACRO software to test the hypotheses posited (Hayes, 2012).

Results of linear regression analyses showed that there was a statistically significant relationship between positive schizotypy, as measured by the MIS (N = 95, M = 8.17, SD = 5.20), and apophenia, as measured by the ASI (N = 95, M = 13.70, SD = 6.45), $F(1, 94) = 62.58$, $p < .000$, $\beta = .632$ (see **Table 4**). In addition, regression analyses also showed a statistically significant relationship between positive schizotypy, as measured by the MIS, and task performance on the RDT (i.e., the false positive sums), $F(1, 91) = 9.97$, $p < .002$, $\beta = .314$ (see **Table 5**). Because of parametric shortcomings mentioned elsewhere, a square root transformation was made on the DV, namely, the RDT, to better approximate normality for the variable. The results of this analysis were, qualitatively speaking, not importantly different, $F(1, 91) = 9.05$, $p = .003$, $\beta = .301$ (see **Table 5**). These results suggest that 1) individuals who are higher in positive schizotypy tend to report higher levels of apophenia, and 2) that individuals who are higher in positive schizotypy tend to commit and display greater type 1 error frequency and salience misattribution.

Using Hayes Process Macro software (Hayes, 2012), the results of a model 4 mediation analysis showed that there was no statistically significant mediation effect of apophenia on the relationship between positive schizotypy and task performance on the RDT, *indirect effect*(*s*) = .015, CI (−.1088, .1443) (see **Table 6**). In addition, the *b path* in the model (i.e., the relationship between apophenia and task performance) was not statistically significant, $t(90) = .1857$, $p = .8531$, $\beta = .024$. A supplemental analysis of square root transformations of the DV yielded qualitatively identical and non-significant results, *indirect effect*(*s*) = .001, CI (−.1413, .1522) (see **Table 6**). These results suggest that apophenia does not mediate the relationship between positive schizotypy and task performance.

Table 2. Summary statistics of variables.

Variable (Range)	Mean (SD)
MIS (0 - 30)	8.17 (5.20)
ASI (0 - 29)	13.70 (6.45)
RDT (0 - 60)	5.63 (6.47)

Table 3. Bivariate correlations of variables.

	MIS	ASI	RDT
MIS	1.00	-	-
ASI	.632*	1.00	-
RDT	.314*	.210	1.00

Note. MIS = Magical Ideation Scale, ASI = Aberrant Salience Inventory, RDT = Random Dots Task; *$p < .05$.

Table 4. Relationship between schizotypy and apophenia.

Measure (Variable)	R	R²	R² Adj.	F (1, 91)	p
MIS (Positive Schizotypy)*	.632	.400	.393	62.581	<.0001

Note. *Illustrates the positive, statistically significant relationship between apophenia (as measured by the ASI) and positive schizotypy (as measured by the MIS).

Table 5. Relationship between positive schizotypy and task performance.

Measure (Variable)	R	R²	R² Adj.	F (1, 91)	p
MIS (Positive Schizotypy)*	.314	.099	.089	9.970	.002
MIS (Positive Schizotypy)**	.301	.090	.080	9.046	.003

Note. *Illustrates a positive, statistically significant relationship between positive schizotypy (as measured by the MIS) and type 1 error pattern detection (as measured by the RDT). **Results of analysis with transformed DV (RDT).

Table 6. Results of mediation analysis.

	Standardized β	t (90)	p	95% C.I.
Indirect Effects*	.015	.185	.853	[−.108, .144]
Indirect Effects**	.001	.024	.981	[−.141, .152]

Note. *Illustrates no statistically significant mediation effect of apophenia on the relationship between positive schizotypy and task performance on the RDT. ** Results of analysis with transformed DV (RDT).

4. Discussion

In summary, this study attempted to analyze, differentiate, and predict the relationship between the concepts of positive schizotypy and apophenia in a sample of non-clinical college students based on the dimensional model of schizotypy found in research. Participants completed self-report measures of positive schizotypy and apophenia before completing an experimental task involving pattern recognition, type 1 error, and salience misattribution. The study is informative and useful in our understanding of the nature of positive schizotypy and its cognitive/perceptual features involving the perception of meaningful patterns where none exist. This research contributes to both our understanding of this extended phenotype and provides further insight into what differentiates it from other conceptualizations within which aberrant salience and propensities toward type 1 errors are observed. The results of the study showed that these concepts, namely, positive schizotypy and apophenia, do not exist in relation to one another in the manners of relation predicted, thus complicating the measurement of positive schizotypy. Although these findings supported our hypothesis that individuals higher in positive schizotypy would report higher levels of apophenia, more meaningful pattern detection, and thus less accuracy in the experimental task (greater type 1 error frequency) than would individuals lower in positive schizotypy, apophenia did not behave as a mediator in the relationship between positive schizotypy and task performance, thus not supporting our

second hypothesis.

There are a few things worth mentioning regarding the lack of support for the second hypothesis. Related to the statistical limitations touched on elsewhere, the restricted range of the experimental task may be one explanation for this negative finding (Tabachnick & Fidell, 2018). A second potential explanation involves the measures of positive schizotypy and apophenia; each of these measures (MIS and ASI, respectfully) are highly correlated with one another, and yet, only the MIS explains a decent amount of the variance in experimental task performance. This may suggest that what the RDT performance is truly capturing is that which is uniquely being measured by the MIS, for which, psychotic symptom development is a fair candidate. Another possibility for this finding is that magical thinking, and not apophenia or positive schizotypy per se, is what is being picked up by task performance.

There are a set of limitations in this research, the majority of which seem to be conceptual and statistical in nature. Conceptually, one limitation was the failed attempt at discovering an assessment that measured positive schizotypy proper. The MIS is meant to measure beliefs in magical or superstitious forms of causation, as well as being predictive of psychotic symptom development (Eckblad & Chapman, 1983). Although it is claimed to be one of the most valid measures of positive schizotypy, the MIS still may be more of a distal proxy than would be ideal (Eckblad & Chapman, 1983). Much of the past research on positive schizotypy has used the Perceptual Aberration Scale to measure the construct (Chapman, Chapman, & Raulin, 1978). We did not include this measure as it would not have been appropriate or sufficiently relevant for the investigations of this paper; for example, the majority of the items assess variables related to the perception of one's own body (Chapman, Chapman, & Raulin, 1978). In addition, of all the items on the measure, only seven of them are not specific to body perception (Chapman, Chapman, & Raulin, 1978). Thus, this measurement approach was too univariate and unrelated to the goals of this investigation. Another conceptual limitation of the research is the experimental task used to detect salience misattribution/aberrant salience. Although in theory the RDT is ideal for assessing the attribution of meaning to meaningless stimuli, it restricts investigation to visual stimuli only, and does not allow for an assessment of global, nonvisual, or abstract information-based erroneous pattern detection (Jakes & Hemsley, 1986). It could be considered a possibility that this is the reason that no mediation effect of apophenia was observed. This is to suggest that perhaps apophenia is not as *visual* a phenomenon as previously thought; maybe the visual perception component of the salience misattribution and erroneous pattern detection characteristic of apophenia is indicative of more severe instantiations of the disposition. Perhaps a milder instantiation of apophenia takes place in more abstract information space, as opposed to visual sense data. Regardless, the authors were unsuccessful in discovering a task that assessed salience misattribution or type 1 error detection in abstract information. This may be a place for future research

in the measurement of these phenomena.

Like the RDT, there are other non-self-report measurements and assessments of type 1 errors and erroneous pattern detection related positive schizotypy and apophenia that have been used in previous research (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020; Brugger & Graves, 1997; Fyfe, Williams, Mason, & Pickup, 2008; Galdos et al., 2011; Grant, Balser, Munk, Linder, & Hennig, 2014). One central weakness of these other non-self-report measurements is the innate task-specific confounding variables, an observation that has been made elsewhere (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020). Some of these tasks require and or involve things such as counting, psychomotor function, numeracy, literacy, social aspects/theory of mind (ToM), paranoia, audition, processing speed, writing, IQ, and facial recognition (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020; Brugger & Graves, 1997; Fyfe, Williams, Mason, & Pickup, 2008; Galdos et al., 2011; Grant, Balser, Munk, Linder, & Hennig, 2014). The RDT task only involved and required visual perception and verbal reporting (i.e., looking at a computer screen and reporting what was or wasn't observed). The RDT, which was used to assess erroneous pattern recognition, salience misattribution, type 1 error propensity, etc., was selected because it was, at the time of the research design, 1) the only known task that was devoid of these intrinsic confounding variables mentioned above, and 2) so avoided the possibility of unintentionally measuring these irrelevant variables and yielding skewed data. This observation suggests that this research contributes to the literature on type 1 error propensity in positive schizotypy and apophenia.

Other potential limitations are statistical in nature. Although power analyses found it *generally* sufficient in an analytic sense, the relatively small sample size in the study is another limitation. A greater sample size would have meant more data, which would have been more representative, and would have likely changed some quantitative characteristics of the variables, as well as their relationships with one another. Factors related to the COVID-19 virus at the time of data collection were large contributors to the relatively smaller and restricted sample size. A second statistical limitation was the nonparametric qualities of a few of the variables and their relationships to one another. However, the results of the supplemental analyses (i.e., transformation analyses) did not differ qualitatively in any meaningful way from the parametric analyses, and so more thoroughly supported the findings. That being said, these nonparametric qualities made the task of data analysis and interpretation more arduous than would have been otherwise. For example, necessary variable transformations yield difficulties in data interpretation for the purposes of clinical application, and this may occur for dimensional data in non-clinical populations.

5. Conclusion

It could reasonably be claimed that, overall, the results of this study warrant

further research on the topics therein, given that said results were not entirely consistent with other studies (Carson, Peterson, & Higgins, 2003; DeYoung, Grazioplene, & Peterson, 2012; Kwapil & Barrantes-Vidal, 2015; Partos, Cropper, & Rawlings, 2016). In light of these results, it remains unclear as to how and why positive schizotypy and apophenia appear to have many shared and overlapping characteristics at multiple levels of investigation and analysis, which presents a puzzling psychometric and measurement issue (Carson, Peterson, & Higgins, 2003; DeYoung, Grazioplene, & Peterson, 2012; Kwapil & Barrantes-Vidal, 2015; Partos, Cropper, & Rawlings, 2016). There does not appear to be a complete understanding as to the nature of how these concepts behave in the presence of one another. One possibility hinted at previously is that there are as of yet undiscovered subtypes of apophenia that arise from a more general underlying latent structure, some of which may be more visual in nature, and perhaps others that are more conceptual and abstract (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020). It is possible that the common denominator of apophenia (erroneous pattern detection/type 1 error propensity/salience misattribution) could exist *uniquely* for multiple sensory data modalities, and for abstract operations of belief and meaning as well (Blain, Longenecker, Grazioplene, Klimes-Dougan, & DeYoung, 2020). Given the findings of this research, this could arguably qualify as a reasonable hypothesis and implication moving forward.

Future research should strive to recruit larger samples sizes. There seems to likely be value in using nonclinical samples to research constructs that appear to exist dimensionally, like other psychosis-related variables such as paranoid ideation (Combs, Michael, & Penn, 2006). In addition, one aspect of future research that may not be wise to neglect is measurement. Specific and psychometrically sound, valid, and reliable assessments of positive schizotypy, apophenia, and aberrant salience would be of high utility in achieving a thorough understanding of these phenomena. Clearly, having a well-defined and differentiated set of measures would be valuable. In the past few years, there have been other tangentially related areas of research that have made progress on this front. For example, the study of social cognition in disorders such as schizophrenia was previously more difficult partly due reasons related to construct validity and measurement, but more recent research progress involving measurement accuracy has improved understanding and comprehensive insight in the area of study (Riedel, Horan, Lee, Hellemann, & Green, 2021; Roberts & Penn, 2013). This kind of research progress is not only influential and relevant to work done here in the United States, but it also can and has extended out to other countries abroad (Charernboon & Patumanond, 2017).

In closing, the purpose of this study was to investigate the relationships between positive schizotypy, apophenia, and pattern recognition. The results suggested that although these concepts do appear to overlap in multiple ways, a complete understanding of the structure and mechanisms of their relationships with one another remains elusive.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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