



RESEARCH PAPER

Exploring the Relationship between Empathy, Prosocial Behavior and Birth Order among Adolescents and Young Adults

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ABSTRACT

This research investigated the relationship between empathy and prosocial behavior among adolescents and young adults, considering the role of birth order. In a world shaped by empathy and kindness, understanding what drives people to help others has never been more important. A quantitative, correlational survey design was employed, and data was collected from 226 participants (154 females, 72 males) aged 13–40 years using a convenience sampling technique. The Toronto Empathy Questionnaire (TEQ) and Prosocial Behavior Scale were used to measure the variables. Two hypotheses were tested using correlational analysis and One-Way ANOVA via SPSS version 25. Results revealed a significant relationship between empathy, birth order, and prosocial behavior. However, no significant difference was found in empathy and prosocial behavior based on birth order. An important implication is that early evidence-based empathy training and positive parenting can nurture emotionally secure, prosocial individuals. Future research may benefit from using larger, more diverse samples to validate these findings.

KEYWORDS Empathy, Birth Order, Prosocial Behavior, Adolescents, Young Adults

Introduction

The term 'empathy' was devised over a hundred years ago by Titchener, an edition of the German word *Einfühlung* (Wispé, 1986). Empathy highlights the natural ability to differentiate and be sensitive to the emotional states of others, attached with a motivation to worry for his or her well-being. According to Davis (1983) "Empathy states the thoughts and feelings of an individual in response to the observed (emotional) experiences of another person". However, Batson identified two kinds of empathy. The primary definition refers to "knowing the internal state of an individual, perspective taking, empathic accuracy, and theory of mind". This kind of empathy is mentioned as Cognitive Empathy. The second definition proposed refers to feeling the "same emotion that another person feels" and has been mentioned as Emotional Empathy (Batson, 2009). Persons may determine different empathic responses due to varying emotional regulation abilities. Eisenberg suggests that empathic responses arise from affective empathy, and may cause to the presence or absence of pro social behavior (Eisenberg et al., 2010; Eisenberg & Eggum, 2009).

Prosocial behavior is defined as "Behavior intended to help another person" (Eisenberg, Fabes & Spinrad, 2006). Pro social (helping) behavior has been theoretically and empirically interconnected to a variety of positive personal and socio emotional variables including perspective taking, moral judgment, empathic responding, emotion regulation, positive emotionality, and positive peer and parental relationships. In contrast, a lack of pro social behavior has been related to poor social adjustment, like peer rejection (Crick, 1996).

Birth order is assumed to play an outsized role in people's lives and the way they act. Studies predict impact of birth order on pro social behavior. Birth order also referred to as ordinal position is a concept that has been studied for several years and it is thought to play a significant role within the way people behave. Being the firstborn, middle child, last-born, or only child may affect the behavior of adolescents and young adults.

Adler was among the first theorists to include the concept of birth order into his work and theorized that every birth position features a set of personality traits related to it. First-borns have an exceptional place within the family. The oldest child has responsible behavior. They are supposed as more hard-working and achieving than other children in family (Paulhus, Trapnell, & Chen, 1999). First borns are more driven towards work and competition and have leadership abilities, are more logical, organized, aggressive, scholarly, low risk takers, set goals and reach them, tend to urge more done each day than others. Middle born children, on the opposite hand, may experience difficulty finding an edge of honor and significance within the family because they never have the chance to monopolize parents' attention (Adams, 1972) and is taken into account the foremost difficult of all birth positions. Thus, they persistently fight to stay ahead of their younger siblings. The middle child of three is usually different from the middle child of an outsized family. The middle children of large families are often less competitive as parents don't have maximum time to offer each child and so the children learn to cooperate to urge what they need. When it comes to last born, they are more human-related and are not so motivated towards the work. They are more interested in maintaining good relationships instead of achieving in work (Forer & Still, 1976). Last born behave like only child and assume others to do things, make decisions and take responsibility. Due to how they are treated or handled, they become boss of the family in getting service from others and having their own way.

Adolescence is often a time of both confusion and innovation. According to Charles Darwin and G. Stanley Hall adolescence is defined as a period of "storm and stress, a time of universal and of inevitable upheaval". Young adulthood is a time often perceived as the key stage of life when one is free from both the chains of adolescence and therefore a stigma that accompany with more advanced age. According to Erik Erikson's stages of human development, "a young adult is an individual between the ages of 20 and 39" emerging from the look for and persistence on identity, is keen and willing to fuse their identity thereupon of others. As individuals emerge from adolescence, their dependence on family diminishes as they start to determine autonomy, careers, and intimate relationships throughout the subsequent two years of life.

The theoretical structure of this research is grounded in three key theories that explain the interplay between birth order, personality traits, empathy, and prosocial behavior. Adler's Birth Order Theory suggests that a child's position in the family influences their personality development, with distinct traits attributed to firstborns, middle children, and lastborn (Adler, 1927). Building on Adler's ideas, Sulloway's Theory highlights how birth order affects the Big Five personality traits, particularly emphasizing that later-born children tend to be more agreeable, open, and altruistic—traits closely linked to empathy (Sulloway, 1999). The Empathy-Altruism Theory further explains that individuals who experience empathic concern are intrinsically motivated to help others, regardless of personal gain (Batson, 1991). Together, these theories provide a framework where birth order shapes personality traits such as empathy, which in turn drives prosocial behavior.

Literature Review

Empathy and prosocial behavior in children are deeply shaped by the quality of parent-child relationships. Research shows that parental support, expectations, and healthy communication significantly foster these traits. Strong emotional bonds and

psychological guidance from parents promote lasting social competence. Parental influence is thus key to adolescents' empathic and prosocial development (Feng, Yoo & Day, 2013). Hoffman (2008) demonstrates that perspective-taking skills are essential for empathic reactions. In contrast to other-oriented thought, perspective taking contributes to empathic concern, which can lead to prosocial behavior. The social and emotional responses of a child from parents, peers, and media may also affect empathy development and delay the development of prosocial behavior (Eisenberg & Mussen, 1989).

Research shows that people are more likely to act prosocially toward those they perceive as similar to themselves (Osbeck, Moghaddam & Pereault, 1997). While similarity increases prosocial responses, its direct effect on empathy remains less explored. However, perceived similarity—especially in shared experiences or traits like age and gender—has been linked to greater empathic concern in both children and adults (Eisenberg & Miller, 1987).

For a long time, birth order has been a subject of debate among researchers. One of the first to integrate birth order into psychological theory was Alfred Adler in 1918. He emphasized that a child's position in the family constellation is a significant factor (Adler, 1927). Adler focused much of his research on the firstborn, second-born, youngest, and only child. The firstborn initially enjoys the full attention of parents but is later "dethroned" with the birth of a sibling. This shift often results in a need to compete for attention. The second-born child, attempting to catch up to the elder sibling, becomes highly competitive (Olson & Hergenhahn, 2011). Snow, Jacklin, and Maccoby (1981) highlighted gregariousness and boldness as typical traits of firstborn individuals.

Middle-born children are often found to be effective negotiators and peace-makers, forming stronger connections with friends than with family (Sulloway, 1996). Intrapersonal abilities regulated by emotional consistency have also been found to be higher in middle-borns compared to earlier-born siblings (Kaur & Dheer, 1982). This is supported by a review by Eckstein et al. (2010), which examined 200 birth order studies and concluded that youngest children tend to be more common, empathic, and socially engaged—traits that reflect strong interpersonal skills. Conversely, Gupta (2017) discovered that later-borns were often extroverted, defiant, pleasant, and at times manipulative. Blair (2011) reported similar findings.

Researchers have also explored how birth order influences prosocial behavior. For example, Eisenman (1992) reported that firstborns exhibit higher levels of anxiety and imagination than others. Dunn and Munn (1986) observed that older siblings are more likely to act in a prosocial manner, especially when interacting with younger siblings. This finding was supported by Parke and Buriel (2006) who emphasized the presence of real prosocial actions among older siblings in sibling relationships.

Empathetic individuals are more prone to expressing prosocial behavior, particularly in situations where help is needed, as those who understand others' emotions are more likely to respond. While the exact influence of birth order on intelligence, character, and behavior remains debated, some argue that individuals unconsciously make decisions based on beliefs tied to their birth order position (Herrera et al., 2003; Olson & Hergenhahn, 2011).

Material and Methods

This research followed a quantitative, correlational survey design to explore the relationship between empathy, prosocial behavior, and birth order. Data were collected online using Google Forms. A total of 226 Pakistani participants (154 females, 72 males), aged 14–36, were recruited via convenience sampling. The sample included 30 adolescents (13–18) and 196 young adults (19–40). Inclusion required internet access and English

comprehension, while individuals outside the age range, non-residents, those without internet access, or with mental disabilities were excluded.

The measures included an informed consent form, a brief demographic information form, the Toronto Empathy Questionnaire (TEQ), and the Prosocial Behavior Scale (PBS). The Toronto Empathy Questionnaire, developed by Spreng et al. (2009), is a 16-item scale measuring emotional empathy using a 5-point Likert scale ranging from "Never" to "Always." It includes positively and negatively worded items, with strong internal consistency ($\alpha = 0.85-0.87$). Moreover, the Prosocial Behavior Scale, developed by Caprara et al. (2005), is also a 16-item self-report scale assessing prosocial behavior across four domains: sharing, helping, caring, and empathic concern. Responses are rated from 1 (Never) to 5 (Almost Always), with high internal consistency ($\alpha = 0.91$). Both tools were used with permission from the original authors.

After obtaining permission to use the scales, the online survey was created and shared via social media platforms. Participants provided informed consent before completing the form. Ethical considerations included voluntary participation, the right to withdraw, anonymity, and protection from harm. No deception was used, and contact information was provided for participants wishing to follow up. Data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.

Results and Discussion

The results of the study were computed and analyzed by conducting a series of statistical analyses using the Statistical Package for Social Sciences (SPSS 25.0). The following tables show obtained results along with their interpretations.

Table 1 shows the frequency and percentages of demographic variables, while Table 2 demonstrates the descriptive statistics of the scales. While tables 3-4 shows the correlation between Empathy, Prosocial Behavior and Birth Order, and the effect of different birth orders on Empathy and Prosocial behavior.

Table 1
Frequency and Percentages of Demographic Variables (N=226)

Variables	<i>f</i>	%
Gender		
Male	72	31.9
Female	154	68.1
Birth Order		
First born	88	38.9
Middle born	92	40.7
Last born	46	20.4
Marital status		
Single	162	71.7
Committed	18	8
Engaged	20	8.8
Married	26	11.5
Family structure		
Nuclear	160	70.8
Joint	66	29.2
Occupation		
Student	143	63.3
Part time student	12	5.3
Professional	65	28.8

Others	6	2.7
Monthly income		
<50,000	125	55.3
50,000-99,999	56	24.8
100,000-200,000	30	13.3
>200,000	15	6.6

Note: Table 1 illustrate the distribution of frequency and the percentages of the demographic variables that were considered in the present study.

Table 2
Descriptive statistics and Alpha Reliability coefficients, univariate Normality of Study Variables (N=226)

Scales	Items	α	M	SD	SK	K	Range	
							Actual	Potential
Empathy	16	0.71	45.92	8.14	-0.02	-0.68	25-64	0-64
Prosocial Behavior	16	0.95	62.74	14.28	-1.17	0.87	16-80	16-80

Note: α = Cronbach's alpha, SD= Standard Deviation, M= Mean, K= Kurtosis SK= Skewness.

The above table demonstrates the value of Mean, Skewness, Standard Deviation, Kurtosis, Cronbach alpha reliability and the Actual and Potential Range for each scale, that were computed to get descriptive information about the sample. The values of kurtosis and skewness indicates that the data is distributed normally.

The empathy scale has alpha value of 0.71 which indicates good and acceptable reliability whereas, the Prosocial behavior scale has Cronbach's alpha value of 0.95 which indicates excellent internal consistency.

Table 3
Correlation among Empathy, Prosocial behavior and Birth order.

Variable	Empathy	Prosocial behavior	Birth order
Empathy	-	0.48**	-0.17**
Prosocial behavior		-	-0.16*
Birth order			-

Note: **Correlation is significant at the 0.01 level of significance (2-tailed)

*Correlation is significant at the 0.05 level of significance (2-tailed)

The above-mentioned table shows the relationship among the variables under study. The table denotes a significant weak positive correlation (0.48) between Empathy and Prosocial behavior. The table also indicates a significant weak negative correlation (-0.17) between Empathy and Birth order. Moreover, the correlation between Prosocial behavior and Birth order is found to be significantly weak negative (-0.16). These results prove the first hypothesis which stated that there would be a significant relationship between empathy, prosocial behavior, and birth order among adolescents and young adults.

Empathy facilitates everyday social interactions and has often linked pro social behavior. This hypothesis was proven true, as shown in Table 3. Empathy was found to have significant positive, weak relationship with pro social behavior. However, empathy and pro social behavior had a significant weak relationship with birth order. The results of the study highlight the idea that empathetic people are more prone to express pro social behavior in a situation where help is needed because people who understand others' feelings and empathize with others tend to help them if they can, hence the positive relationship between the two. This is in accordance with the study conducted by Carrizales (2018) to discover the relation between empathy and pro social behavior. The study highlighted that empathy is an important motivator of pro social behavior. In the study,

findings indicate the factors like extracurricular peer group characteristics, family characteristics and parent's pro social behavior play a significant role in the pro social behavior through empathy in adolescence. One such example has been described in a study which concluded that younger born children shows higher levels of empathy than first and only born children (Scotland & Walsh, 1963) that shows that as birth order decreases, level of empathy increases.

One of the factors that impacts the level of pro social behavior is Birth order. Results indicates that birth order has a significant weak influence on pro social behavior such that later birth orders demonstrate higher pro sociality as well as some studies reveals that younger born too demonstrate high level of pro social behavior. A study by Salmon, Cuthbertson, & Figueredo, (2016) revealed that a substantial increase in pro sociality is observed between first and second born. While Forer & Still (1976) reflects that later born are more human-oriented, they are more interested towards maintaining good relationship hence, leading towards pro sociality.

Table 4
One Way Analysis of Variance (ANOVA) showing the effect of birth order on Empathy and Prosocial behavior

Variable	First Born N=88		Middle Born N=92		Last Born N=46		F	Sig.	95% CI	
	M	SD	M	SD	M	SD			LL	UL
Empathy	47.04	7.9	45.07	8.09	45.5	8.6	1.40	0.24	44.8	46.9
Prosocial Behavior	63.3	14.3	64.13	13.49	58.8	15.4	2.19	0.11	60.8	64.6

*p<0.05

The above-mentioned table denotes the second hypothesis, as hypothesized that there would be a significant difference between empathy and prosocial behavior based on birth order. The results indicate no significant difference in the scores of empathy and prosocial behavior based on Birth order.

Relatively few studies have explored the relationship between empathy and prosocial behavior based on birth order. In this research, ANOVA results revealed no significant difference in empathy and prosocial behavior across birth order groups. This finding contrasts with prior literature suggesting that later-born individuals—particularly middle and younger siblings—are more likely to show empathy and engage in prosocial behaviors.

Based on these results, the hypothesis was not supported, and the null hypothesis was retained. This indicates that empathy and prosocial behavior do not significantly vary with birth order, suggesting all birth orders may share similar levels of these traits. Although a weak correlation was observed between birth order and both empathy and prosocial behavior, this was insufficient to indicate meaningful group differences. This supports the idea that while empathy and prosociality are related, birth order may not be a defining factor in their expression.

Previous research has presented mixed evidence. For instance, Eisenberg et al. (1996) suggested that middle-borns may show greater prosocial behavior, and Eckstein (2000, 2010) argued that last-borns are often more empathic. Similarly, Salmon, Cuthbertson, and Figueredo (2016) highlighted the sociability and fun-loving nature of later-borns, which may contribute to prosocial tendencies. However, other studies align more closely with the current findings. Gordon (2012) found no significant difference between birth order and empathy. Rohrer, Egloff, and Schmukle (2015) further argued that birth order does not have lasting effects on broad personality traits such as agreeableness, emotional stability, or extraversion.

While not statistically significant, this study found that first-borns had the highest mean empathy scores ($M = 47.04$), while middle-borns scored highest in prosocial behavior ($M = 64.13$). It was previously assumed that birth order could influence personality traits like empathy or prosociality. However, these findings suggest that birth order may not play a central role, and other factors may contribute more significantly to individual differences in these traits.

Conclusion

The research aimed to explore key psychological and social factors influencing empathy and prosocial behavior in adolescents and young adults, with a particular focus on birth order differences. Findings revealed a significant but weak positive correlation between empathy and prosocial behavior, and a weak correlation between empathy and birth order. No significant differences were observed in empathy or prosocial behavior based on birth order. These results highlight that while empathy and prosocial behavior are linked, their development may be influenced more by individual and contextual factors than by demographic variables like birth order. Further research is recommended to explore other contributing factors that may shape these traits.

Recommendations

For future ventures, larger sample size is recommended. Studies can also be carried out to identify other factors in which birth order plays a crucial role. It is recommended that survey forms should be filled in person, in this way non-serious attitude of participants (if any) could be minimized. Future researchers can try using larger, more representative samples to replicate this result. Moreover, this research helps guide future researchers looking to understand similar issues that may occur in the future.

References

- Adams, B. N. (1972). Birth order: A critical review. *Sociometry*, 35(3), 411–439. <https://doi.org/10.2307/2786503>
- Adler, A. (1927). *Understanding human nature* (8th ed.). Greenberg.
- Blair, L. (2011, January 28). *First-born? Piggy in the middle? Or always the baby? How your place in the family rules your life*. Mail Online; Daily Mail. <https://www.dailymail.co.uk/femail/article-1351567/First-born-Piggy-middle-Or-baby-How-place-family-rules-life.html>
- Carrizales, A. (2018). *The role of living environments on empathy and prosocial behaviours development in adolescence* (Doctoral dissertation, Université de Bordeaux).
- Crick, N. R. (1996). The Role of Overt Aggression, Relational Aggression, and Prosocial Behavior in the Prediction of Children's Future Social Adjustment. *Child Development*, 67(5), 2317. <https://doi.org/10.2307/1131625>
- Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, 44(1), 113–126. <https://doi.org/10.1037/0022-3514.44.1.113>
- Decety, J., & Ickes, W. (Eds.). (2009). *The Social Neuroscience of Empathy*. The MIT Press. <https://doi.org/10.7551/mitpress/9780262012973.001.0001>
- Dunn, J., & Munn, P. (1986). Siblings and the Development of Prosocial Behaviour. *International Journal of Behavioral Development*, 9(3), 265–284. <https://doi.org/10.1177/016502548600900301>
- Eckstein, D. (2000). Empirical Studies Indicating Significant Birth-Order-Related Personality Differences. *Journal of Individual Psychology*, 56(4).
- Eckstein, D., Aycock, K. J., Sperber, M. A., McDonald, J., Wiesner, V. V., Watts, R. E., & Ginsburg, P. (2010). A review of 200 birth order studies: Lifestyle characteristics. *The Journal of Individual Psychology*, 66(4), 408–434.
- Eisenberg, N., & Miller, P. A. (1987). The relation of empathy to prosocial and related behaviors. *Psychological Bulletin*, 101(1), 91–119. <https://doi.org/10.1037/0033-2909.101.1.91>
- Eisenberg, N., & Mussen, P. H. (1989). *The roots of prosocial behavior in children*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511571121>
- Eisenberg, N., Fabes, R. A., Karbon, M., Murphy, B. C., Wosinski, M., Polazzi, L., Carlo, G., & Juhnke, C. (1996). The Relations of Children's Dispositional Prosocial Behavior to Emotionality, Regulation, and Social Functioning. *Child Development*, 67(3), 974–992. <https://doi.org/10.1111/j.1467-8624.1996.tb01777.x>
- Eisenberg, N., Fabes, R. A., & Spinrad, T. L. (2006). Prosocial behavior. In N. Eisenberg, W. Damon, & R. M. Lerner (Eds.), *Handbook of child psychology: Social, emotional, and personality development* (6th ed., Vol. 3, pp. 646–718). Wiley.
- Eisenman, R. (1992). Birth order, development, and personality. *International Journal of Child and Adolescent Psychiatry*, 55, 25–27.

- Forer, L. K., & Still, H. (1976). *The birth order factor: How your personality is influenced by your place in the family*. New York: David McKay Company.
- Gordon, J. (2012). Birth order: investigating its effects on personality, empathy, achievement and perceived academic performance.
- Gupta, T. (2017). Birth Order and Personality. *International Journal of Indian Psychology*, 5(1). <https://doi.org/10.25215/0501.014>
- Herrera, N. C., Zajonc, R. B., Wiczorkowska, G., & Cichomski, B. (2003). Beliefs about birth rank and their reflection in reality. *Journal of Personality and Social Psychology*, 85(1), 142–150. <https://doi.org/10.1037/0022-3514.85.1.142>
- Hoffman, M. L. (2008). Empathy and prosocial behavior. In M. Lewis, J. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of emotions* (3rd ed., pp. 440–455). Guilford Press.
- Kaur, H., & Dheer, V. (1982). Birth order, academic achievement and personality structure. *Indian Journal of Clinical Psychology*, 9, 189–192.
- Olson, M. H., & Hergenhahn, B. R. (2011). *An introduction to theories of personality* (8th ed.). Prentice Hall.
- Osbeck, L. M., Moghaddam, F. M., & Perreault, S. (1997). Similarity and attraction among majority and minority groups in a multicultural context. *International Journal of Intercultural Relations*, 21(1), 113–123. [https://doi.org/10.1016/s0147-1767\(96\)00016-8](https://doi.org/10.1016/s0147-1767(96)00016-8)
- Parke, R. D., & Buriel, R. (2006). Socialization in the family: Ethnic and ecological perspectives. In N. Eisenberg, W. Damon, & R. M. Lerner (Eds.), *Handbook of child psychology: Social, emotional, and personality development* (6th ed., Vol. 3, pp. 429–504). Wiley.
- Paulhus, D. L., Trapnell, P. D., & Chen, D. (1999). Birth order effects on personality and achievement within families. *Psychological Science*, 10(6), 482–488. <https://doi.org/10.1111/1467-9280.00193>
- Rohrer, J. M., Egloff, B., & Schmukle, S. C. (2015). Examining the effects of birth order on personality. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.2704310>
- Salmon, C., Cuthbertson, A. M., & Figueredo, A. J. (2016). The relationship between birth order and prosociality: An evolutionary perspective. *Personality and Individual Differences*, 96, 18–22.
- Snow, M. E., Jacklin, C. N., & Maccoby, E. E. (1981). Birth-Order Differences in Peer Sociability at Thirty-three Months. *Child Development*, 52(2), 589–595. <https://doi.org/10.1111/j.1467-8624.1981.tb03084.x>
- Spreng, R. N., McKinnon, C. M., Mar, R. A., & Levine, B. (2009). The Toronto Empathy Questionnaire: Scale development and initial validation of a factor-analytic solution to multiple empathy measures. *Journal of Personality Assessment*, 91(1), 62–71. <https://doi.org/10.1080/00223890802484381>
- Stotland, E., & Walsh, J. A. (1963). Birth order and an experimental study of empathy. *Journal of Abnormal and Social Psychology*, 66(6), 610–614. <https://doi.org/10.1037/h0049384>

- Sulloway, F. J. (1996). *Born to rebel: Birth order, family dynamics, and creative lives*. Pantheon.
- Sulloway, F. J. (1999). Birth order. In M. A. Runco & S. R. Pritzker (Eds.), *Encyclopedia of creativity* (Vol. 1, pp. 189–202). Academic Press.
- Wispé, L. (1986). The distinction between sympathy and empathy: To call forth a concept, a word is needed. *Journal of Personality and Social Psychology*, 50(2), 314–321. <https://doi.org/10.1037/0022-3514.50.2.314>
- Yoo, H., Feng, X., & Day, R. D. (2013). Adolescents' Empathy and Prosocial Behavior in the Family Context: A Longitudinal Study. *Journal of Youth and Adolescence*, 42(12), 1858–1872. <https://doi.org/10.1007/s10964-012-9900-6>