Research article

Neonatal male circumcision is associated with altered adult socio-affective processing

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ABSTRACT

Background: Neonatal male circumcision is a painful skin-breaking procedure that may affect infant physiological and behavioral stress responses as well as mother-infant interaction. Due to the plasticity of the developing nociceptive system, neonatal pain might carry long-term consequences on adult behavior. In this study, we examined whether infant male circumcision is associated with long-term psychological effects on adult socio-affective processing.
Methods: We recruited 408 men circumcised within the first month of life and 211 non-circumcised men and measured socio-affective behaviors and stress via a battery of validated psychometric scales.
Results: Early-circumcised men reported lower attachment security and lower emotional stability while no differences in empathy or trust were found. Early circumcision was also associated with stronger sexual drive and less restricted socio-sexuality along with higher perceived stress and sensation seeking.
Limitations: This is a cross-sectional study relying on self-reported measures from a US population.
Conclusions: Our findings resonate with the existing literature suggesting links between altered emotional processing in circumcised men and neonatal stress. Consistent with longitudinal studies on infant attachment, early circumcision might have an impact on adult socio-affective traits or behavior.

1. Introduction

Routine, non-therapeutic infant male circumcision is the most commonly performed surgery in the United States (Maeda et al., 2012; Weiss and Elixhauser, 2014). Approximately one-third of males in the world are circumcised (World Health Organization, 2010), primarily for cultural reasons. Nevertheless, the social and health-related aspects of newborn circumcision, including the degree and magnitude of associated benefits and risks, remain contentious and hotly debated (Darby, 2015; Freedman, 2016; Myers and Earp, 2020). Relatively little research has investigated pain-related responses to circumcision in infants (Dixon et al., 1984; Fergusson et al., 2007; Gattari et al., 2013; Gunnar et al., 1981, 1995; Marshall et al., 1980, 1982; Mondzelewski et al., 2016; Page,

2004; Svoboda and Van Howe, 2013; Taddio et al., 1997a, 1997b; Talbert et al., 1976; Williamson et al., 1986; Williamson and Williamson, 1983), and only a handful of studies have generated evidence regarding potential long-term effects lasting into adulthood (Bauer and Kriebel, 2013; Bollinger and Van Howe, 2011; Frisch and Simonsen, 2015a; Ullmann et al., 2017). The small number of studies that have investigated long-term effects have been argued to exhibit methodological flaws and limitations (Boyle, 2017; Morris et al., 2012; Morris and Wiswell, 2015) leading to calls for further research in this area (Bollinger and Van Howe, 2012; Frisch and Simonsen, 2015b).

Indicators of likely infant pain experience overlap considerably with those seen in adults. Administration of noxious stimuli to infants activates 18 of the 20 adult brain regions activated during pain experience

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(Goksan et al., 2015). Due to the plasticity of the developing nociceptive system, the effects of such stimulation may persist into adolescence (AAP, 2016; Hohmeister et al., 2010; Schmelzle-Lubiecki et al., 2007; Walker, 2019). In addition to tracheal intubation or suctioning, catheter insertion, chest tube placement, heel lancing, lumbar puncture, and subcutaneous or intramuscular injections, often associated with neonatal intensive care units (Anand et al., 2001; Simons et al., 2003), penile circumcision is one of the most common sources of pain in (male) newborns. Such circumcision can elicit clinically significant pain responses even when analgesia is used (Banieghbal, 2009, as discussed in Frisch and Earp, 2018), and indications of extreme pain when, as frequently occurs, no analgesia is used (Brady-Fryer et al., 2004; Elhaik, 2018). As recently as the 1990s, large majorities of surveyed physicians reported using no analgesia for newborn male circumcision (Wellington and Rieder, 1993), with many training programs failing to provide any instruction in pain relief for the procedure (Howard et al., 1998).

Because the penile prepuce (foreskin) is normally fused to the head of the penis at birth, these structures must often be forced apart with the application of a blunt probe (Machmouchi and Alkhotani, 2007). Depending on the method, a clamp or other device is then used to crush the prepuce for purposes of hemostasis, followed by excision of the tissue (World Health Organization, 2009). During these procedures, infants' heart rate and blood pressure increase significantly while cortisol levels elevate 3 to 4-fold, remaining elevated up to several days (Gunnar et al., 1981, 1995; Page, 2004; Talbert et al., 1976; Williamson et al., 1986; Williamson and Williamson, 1983). Even with "gold standard" subcutaneous ring blog for analgesia along with intraoperative sucrose, cortisol levels more than double with use of the popular Gomco clamp (Sinkey et al., 2015). Some studies have found that parent-infant bonding following circumcision is disrupted, marked by altered breastfeeding and sleep patterns as well as higher infant irritability (Dixon et al., 1984; Marshall et al., 1982; 1980; Richards et al., 1976; for discussion, see Svoboda and Van Howe, 2013), while others do not find evidence of such behavioral changes (Fergusson et al., 2007; Gattari et al., 2013; Mondzelewski et al., 2016). Circumcised infants display increased pain responses during subsequent vaccination, suggesting that behavioral effects of the surgery can last, at a minimum, up to 4–6 months (Taddio et al., 1997a).

Despite the fact that neonatal circumcision occurs in the US within the most crucial neurodevelopmentally plastic period of an individual's life, very little research has been conducted on its long-term effects. Previous preliminary research has reported an association between circumcision and alexithymia (i.e., dysfunctions in emotion recognition, social attachment, and interpersonal relations) in adults (Bollinger and Van Howe, 2011). More recently, two large-sample studies suggested a positive correlation between circumcision and autism spectrum disorder (ASD; Bauer and Kriebel, 2013; Frisch and Simonsen, 2015a). Although the causal implications of this research has been questioned (Morris et al., 2012; Morris and Wiswell, 2015), these studies suggest that early-circumcision might have an impact on adult psychosocial functioning. It has been extensively debated whether circumcision affects sexual outcome variables, including sensation and satisfaction (e.g., Bossio et al., 2014; Boyle, 2015; Earp, 2016; Morris and Krieger, 2015), with research in this area often conflating studies of newborn versus adult circumcision. It is also contentious whether early-circumcised males experience long-term alterations within the limbic-hypothalamic-pituitary-adrenocortical (LHPA) system; and whether potential stress in this regard is connected to developmental factors. The only study that, to our knowledge, examined this issue was statistically underpowered (Boyle, 2017), using a sample of only 9 circumcised participants (Ullmann et al., 2017). Nevertheless, despite being underpowered, the trend in the data were consistent with the hypothesized decrease in long-term activation of the LHPA axis among early-circumcised males, as assessed through both hair cortisol and cortisone levels (Boyle, 2017; Ullmann et al., 2017). Finally, one recent

study has found that neonatal male circumcision and prematurity were associated with Sudden Infant Death Syndrome (SIDS), providing support for the allostatic load hypothesis (i.e., the result of cumulative perinatal painful, stressful, or traumatic events) as an explanation for SIDS (Elhaik, 2018).

Overall, the research so far suggests that neonatal circumcision is a painful procedure that elicits the stress response and it might have long-term effects. The life-history (or "psychosocial acceleration") theory proposes that early stress, within a period of heightened vulnerability and dependency, such as infancy, leads to the development of a fast (vs. slow) life-history trajectory. Such life-history strategies are hypothesized to be adaptive responses to harsh and stressful environments in order to optimize reproductive and survival fitness, organizing behavior in multiple domains such as risk-taking, self-regulation, resource exploitation, aggression, exploration, sexual maturity, mating, and caregiving (Del Giudice, 2016; Del Giudice et al., 2005; Shakiba et al., 2020). Therefore, in the present study, we explore the relationship between neonatal circumcision and adult psychosocial outcomes, addressing this issue from a stress and developmental perspective. We examine whether early-circumcised men show differences in developmentally-forged traits including personality and attachment styles that, depending on caregiver interactions, appear early in life (Abe and Izard, 1999; DeYoung et al., 2002; Young et al., 2017), and tend to remain stable throughout the lifespan (Young et al., 2017).

Consistent with the life-history theory, we hypothesize that adults who underwent neonatal circumcision, compared to those who did not, will display alterations in socio-affective processing conforming to the fast life-history strategies, namely, decreased reliance on social environment and increased perceived stress and sexual activity. Specifically, here we test whether early-circumcised men, compared to men who did not undergo neonatal circumcision, display higher attachment insecurity and emotional instability (i.e., impaired functioning in emotional, motivational, and social domains), lower empathy and trust, higher sexual libido and unrestricted sociosexuality (i.e., preference of short- over long-term mating), as well as higher stress and risk taking attitudes.

The present research is framed within the context of developmental and socio-affective psychology. Therefore, questions about whether neonatal circumcision is ethical (Abdulcadir et al., 2019; Benatar and Benatar, 2003; Earp, 2013), is associated with therapeutic benefit (e.g., reduction in sexually transmitted and urinary tract infections as well as penile cancer; AAP, 2012; Dave et al., 2018; Frisch et al., 2013) or risks (e.g., meatal stenosis, loss of the glans or the whole penis; Fahmy, 2019; Krill et al., 2011), or changes in sexual sensation, function, satisfaction, or body image (Bossio et al., 2016; Bossio and Pukall, 2018; Earp, 2016; Hammond and Carmack, 2017), fall outside the scope of this research.

2. Method

2.1. Participants

A total of 744 Amazon Mechanical Turk (MTurk) participants completed an online survey using the TurkPrime interface between July and December 2017. TurkPrime is a research platform linked with MTurk and supports tasks that are common to the social and behavioral sciences (Litman et al., 2017). MTurk respondents are a subset of workers who decide to complete a given task; hence participation is voluntary (Stewart et al., 2017). Because circumcision is sometimes associated with religious practice, here we attempted to limit this potentially confounding variable. To do this, we chose a general US sample since neonatal circumcision is commonly practiced in the US within the first week of life regardless of religious faith. All participants were currently living in the US, which ensured language competence when completing self-report questionnaires (Chandler and Shapiro, 2016; Litman et al., 2015).

Table 1. Demographic characteristics of early-circumcised (EC) and non-circumcised (NC) participants.

Total		Total sample		Early circumcised		Non circumcised		
		619		408	69.27%	211	35.82%	
Age [mean SD]		34.91	9.99	35.98	10.36	32.85	8.90	$t_{484.39} = 3.91$, p < .001
Circumcision reasons		N	%	N	%	N	%	
Hygiene				91	22.30%	-	-	
I don't know why				236	57.84%	-	-	
Medical reasons				24	05.88%	-	-	
Other				10	02.45%	-	-	
Religion				47	11.52%	-	-	
	missing			0	00.00%			
Ethnicity								
Black or African American		46	07.43%	28	06.86%	18	08.53%	
Hispanic or Latino		49	07.92%	13	03.19%	36	17.06%	
White		462	74.64%	341	83.58%	121	57.35%	
Other		58	09.37%	22	05.39%	36	17.06%	$X^2_3 = 67.16$, p < .001
	missing	4	00.65%	4	00.98%	0	00.00%	
Sexual orientation								
Bisexual		24	03.88%	15	03.68%	9	04.27%	
Heterosexual		571	92.25%	379	92.89%	192	91.00%	
Homosexual		21	03.39%	12	02.94%	9	04.27%	
Other		3	00.48%	2	00.49%	1	00.47%	$X^2_3 = 0.90$, p = .826
	missing	0	00.00%	0	00.00%	0	00.00%	
Is in a relationship								
No		247	39.90%	153	37.50%	94	44.55%	
Yes		346	55.90%	240	58.82%	106	50.24%	$X^2_1 = 3.55$, p = .060
	missing	26	04.20%	15	03.68%	11	05.21%	
Education								
Bachelor		288	46.53%	189	46.32%	99	46.92%	
High School		244	39.42%	155	37.99%	89	42.18%	
Master		53	08.56%	40	09.80%	13	06.16%	
More than one Master		5	00.81%	5	01.23%	0	00.00%	
PhD		4	00.65%	3	00.74%	1	00.47%	
Primary		1	00.16%	0	00.00%	1	00.47%	
Technical		24	03.88%	16	03.92%	8	03.79%	$X^2_6 = 7.46$, p = .281
	missing	0	00.00%	0	00.00%	0	00.00%	
Occupation time								
Career of home, family, etc. full time		2	00.32%	1	00.25%	1	00.47%	
Other permanently unemployed e.g. chronically sick, independent means		12	01.94%	10	02.45%	2	00.95%	
Retired		10	01.62%	7	01.72%	3	01.42%	
Student full-time		22	03.55%	9	02.21%	13	06.16%	
Temporarily unemployed but actively seeking work		31	05.01%	22	05.39%	9	04.27%	
Working full- and part-time		542	87.56%	359	87.99%	183	86.73%	$X^2_5 = 8.42$, p = .135
	missing	0	00.00%	0	00.00%	0	00.00%	
Occupation type								
Armed Forces		10	01.62%	8	01.96%	2	00.95%	
Civil Service and local government		21	03.39%	19	04.66%	2	00.95%	
Education		43	06.95%	27	06.62%	16	07.58%	
Finance and banking		60	09.69%	42	10.29%	18	08.53%	
Manufacturing		70	11.31%	44	10.78%	26	12.32%	
Other service industries		177	28.59%	111	27.21%	66	31.28%	
Primary farming, fishing, mining, etc.		12	01.94%	8	01.96%	4	01.90%	
Professions in private practice		107	17.29%	74	18.14%	33	15.64%	
Selling, distribution and retailing		99	15.99%	62	15.20%	37	17.54%	
Transportation		20	03.23%	13	03.19%	7	03.32%	$X^2_9 = 9.24$, p = .415
	missing	0	00.00%	0	00.00%	0	00.00%	

Because we were interested in early (i.e., neonatal) circumcision, we focused on men who stated that they were circumcised within the first month of life (early-circumcised men, EC, N = 408) and men claiming to be non-circumcised (NC, N = 211). Hence the final sample included 619 participants (see Table 1 for demographic characteristics). Respondents were given an anonymous random-generated user ID. Only demographic data (no personal identifiers) were collected. The study was conducted in accordance with the Declaration of Helsinki and informed consent was obtained from all participants before starting the survey. No further ethics approval was required for the conduct of this study since biological samples were not collected, according to the Danish National Committee on Health Research Ethics.

2.2. Material

In contrast with previous online surveys that used titles such as "Global survey of circumcision harm" (Hammond and Carmack, 2017) and "Male circumcision trauma" (Bollinger and Van Howe, 2011), i.e., titles that might have biased participant recruitment, our survey title did not explicitly mention circumcision nor imply any negative connotations to circumcision (for a similar sampling approach, see Earp et al., 2018). Rather, focusing on "Penis morphology and sexual behavior" (see survey instructions in supplementary material, SM1), we asked participants several distractor questions about their penile status to divert attention away from circumcision status in particular. Moreover, in contrast to studies that have recruited participants through foreskin restoration websites, blogs devoted to men's issues, or genital autonomy-related social media, our survey was delivered via TurkPrime, a platform that is neutral with regard to circumcision. This approach, overall, allowed us to minimize selection bias. The survey took approximately 35 min to complete (without an imposed time limit and with the possibility of switching back and forth between questions) and all participants received US $4.00 compensation through their TurkPrime WorkerID (not stored).

The instruments that we used assessed a constellation of socio-affective variables, including attachment styles, personality traits, empathy, interpersonal trust, sexual libido, sociosexuality, stress, and sensation seeking. Attachment style was assessed using the Experiences in Close Relationships-Revised (ECR-R) questionnaire (Fraley et al., 2000), which measures adult attachment avoidance (e.g., "*I prefer not to show a partner how I feel deep down*") and attachment anxiety (e.g., "*I'm afraid that I will lose my partner's love*"). Personality traits were assessed with the Big Five Inventory (Costa and McCrae, 1992), which measures extraversion (e.g., "*I see myself as someone who is talkative*"), openness (e.g., "*I see myself as someone who is original, comes up with new ideas*"), agreeableness (e.g., "*I see myself as someone who is helpful and unselfish with others*"), neuroticism (e.g., "*I see myself as someone who is depressed, blue*"), and conscientiousness (e.g., "*I see myself as someone who does a thorough job*"). In addition, two personality meta-traits, namely, plasticity and stability, were examined by aggregating extraversion and openness for the meta-trait named plasticity, and conscientiousness, neuroticism (reversed), and agreeableness for the meta-trait named stability (DeYoung et al., 2002). The Interpersonal Reactivity Index (IRI, Davis, 1980) was used for assessing empathy via measures of perspective taking (e.g., "*I believe that there are two sides to every question and try to look at them both*") and empathic concern for others (e.g., "*I am often quite touched by things that I see happen*"). Trust was measured with the German Socio-Economic Panel (SOEP, Naef and Schupp, 2009), which includes three dimensions: trust towards institutions (e.g., "*How much trust do you have in parliament?*"), trust towards strangers (e.g., "*How much trust do you have in strangers?*"), and trust towards known individuals (e.g., "*How much trust do you have in friends?*"). Sociosexuality (the preference for short-term mating strategies) was measured with the revised Sociosexual Orientation Inventory (SOI-R, Penke and Asendorpf, 2008). It captures three dimensions of sociosexuality such as behavior (frequency of un-committed sex in the last year, e.g., "*With how many different partners have*

you had sex within the past 12 months?*"), attitude towards uncommitted sex (e.g., "*Sex without love is OK*"), and desire and sexual fantasies to-wards uncommitted sex (e.g., "*In everyday life, how often do you have spontaneous fantasies about having sex with someone you have just met?*"). The Sexual Desire Inventory (SDI, Spector et al., 1996) was used to assess both solitary (i.e., masturbation, e.g., "*How strong is your desire to engage in sexual behavior by yourself?*") and dyadic (i.e., with a partner, e.g., "*How strong is your desire to engage in sexual activity with a partner?*") sexual libido. Stress was assessed using the Perceived Stress Scale (PSS, Cohen and Williamson, 1988), in which participants appraise the overall perceived stress in various situations (e.g., "*In the last month, how often how often have you felt nervous and stressed*"). Sensation seeking, the need for novel experiences, and the willingness to take physical and social risks, was measured with the brief sensation seeking scale (SSS, Hoyle et al., 2002, e.g., "*I like to do frightening things*").

Demographic data included age, ethnicity, sexual orientation, relationship status, education level, occupation type and time, and, if circumcised, the age of, and the reason for, the circumcision. Participants also responded to other measures not included in the present study but part of a broader project that aims at investigating in depth the relation between sexual behavior and circumcision.

2.3. Statistical analyses

The required sample size was determined *a priori* using a statistical power analysis, setting the power (1-β) at 0.95 and α at 0.05, and computing the effect size from the mean and standard deviation (SD) of the stress scale used in Ullman et al. (2017), which is the same as the one used in this study. With an effect size of $d = 0.38$, the projected sample size we needed was 181 participants per group. Thus, to account for potential participant drop out, exclusions, or missing values, we collected data to ensure at least 200 subjects per group.

Data analyses were performed in R (R Core Team, 2019). All measures had Cronbach alphas (computed using the "psych" package, Revelle, 2015) exceeding 0.81 ($M_\alpha = .87$, range = .70 - .95) except for sociosexual behavior ($\alpha = .70$) and trust towards known people ($\alpha = .76$). We then checked for the presence of outliers, defined as values exceeding 2.5 SD from the mean. The percentage of outliers per each dependent variable was below 2% (except for dyadic sexual libido, which was 2.64%, $N_{outliers}$ = 14). Given the negligible number of outliers, we decided not to remove observations nor apply any transformation to the data (for psychometric details, see table SM2 in supplementary material). Before running the main analysis, we performed a discriminant validity test employing a confirmatory factor analysis. All the latent factors loaded the respective items. Results showed satisfactory fit indexes, $\chi^2_{11153} = 23110.53$, $p <$ .001, RMSEA = .06, CFI = .94, SRMR = .06, with all loadings higher than .46 ($ps < .001$) with the exceptions of one loading (lambda = .27, $p <$ .001) of the SOI scale. In addition, all variables represented separate constructs since the 95% confidence intervals did not include 1. Then, we tested whether the two groups, i.e., early-circumcised (EC) and non-circumcised (NC) men, differed in terms of demographic factors. There were differences regarding age ($t_{484.39} = 3.91$, $p < .001$), ethnicity ($\chi^2_6 = 67.16$, $p < .001$), and, marginally, relationship status ($\chi^2_5 = 3.55$, p = .060). Therefore, we decided to include those variables as covariates in subsequent analyses. Also, although marginally significant, we included relationship status as a covariate for theoretical reasons, namely, because of its impact on socio-affective behavior (Fraley et al., 2000; Rodriguez et al., 2015).

Demographic characteristics and distribution of age are reported in Table 1 and Figure 2. In the main analysis, using a multivariate analysis of covariance (MANCOVA), with age, ethnicity, and relationship status as covariates, we examined group differences for multi-domain psychological constructs such as attachment style, personality traits, empathy, trust, sociosexuality, and sexual libido. For each single domain, then, along with stress and sensation seeking, we tested group differences using univariate analysis of covariance (ANCOVA) with the same set of

Table 2. Univariate results. Differences between groups with age, ethnicity, and relationship status as covariates. Negative estimates (b with standard error) indicate lower scores in the non-circumcised group. As measures of effect size and model fitness, partial eta squared (η^2_p, with 95% CI) and R squared (R^2) are reported. df: degrees of freedom.

Psychological construct	scale	Range	b	St. Err	F value	df	p	η^2_p	η^2_p 95% CI	R^2
Attachment	Anxiety	1–7	-.299	0.118	6.44	603	.011	.011	[0.001, 0.032]	.109
	Avoidance	1–7	-.306	0.107	8.22	603	.004	.013	[0.001, 0.037]	.092
Personality	Openness	1–5	.030	0.067	0.19	603	.660	.000	[0.000, 0.009]	.019
	Conscientiousness	1–5	.160	0.071	5.06	603	.025	.008	[0.000, 0.028]	.046
	Extraversion	1–5	.088	0.089	0.99	604	.321	.002	[0.000, 0.014]	.070
	Agreeableness	1–5	.180	0.069	6.72	603	.010	.011	[0.001, 0.033]	.065
	Neuroticism	1–5	-.143	0.087	2.72	603	.100	.004	[0.000, 0.021]	.051
	Stability	0–5	.161	0.063	6.49	603	.011	.011	[0.001, 0.033]	.065
	Plasticity	0–5	.054	0.064	0.70	604	.402	.001	[0.000, 0.013]	.045
Empathy	Perspective taking	1–5	.112	0.080	1.97	600	.161	.003	[0.000, 0.018]	.018
	Empathic concern	1–5	.093	0.085	1.19	600	.275	.002	[0.000, 0.015]	.057
Trust	Towards institutions	1–5	.081	0.067	1.50	520	.222	.003	[0.000, 0.019]	.017
	Towards known people	1–5	.092	0.081	1.29	520	.256	.002	[0.000, 0.018]	.022
	Towards strangers	1–5	.051	0.082	0.38	520	.536	.001	[0.000, 0.012]	.022
Sociosexuality	Behavior	1–9	-.377	0.168	5.00	520	.026	.010	[0.000, 0.033]	.074
	Attitude	1–9	-.465	0.235	3.91	520	.049	.007	[0.000, 0.029]	.028
	Desire	0–9	-.894	0.208	18.44	520	.000	.034	[0.010, 0.070]	.073
Sexual libido	Solitary	0–8	-.354	0.170	4.33	520	.038	.008	[0.000, 0.030]	.039
	Dyadic	0–8	-.430	0.133	10.39	520	.001	.020	[0.003, 0.049]	.069
Stress	Stress	0–5	-.286	0.087	10.76	521	.001	.020	[0.003, 0.050]	.055
Sensation seeking	Sensation seeking	1–5	-.171	0.085	4.08	550	.044	.007	[0.000, 0.028]	.037

covariates. MANCOVAs and ANCOVAs were computed using the function "Anova" from the package "car" (Fox et al., 2014, with type III sum of squares to address differences in group sizes). For all analyses, the significance level was set at α = 0.05. Partial eta squared (η^2_p) is reported as measure of effect size so as to provide the proportion of variance associated only with group differences, partialling out the effects of other covariates. R squared (R^2) is used instead to indicate the overall variance explained by all predictors (group *and* covariates).

3. Results

Circumcision status showed an effect on attachment style ($F_{2,602} = 4.77, p = .009, \eta^2_p = .016$). Specifically, between-subjects effects analysis

indicated that EC participants reported higher levels of avoidance and anxiety compared to the NC sample. No multivariate effect was found regarding the Big Five personality traits ($F_{5,599} = 1.66, p = .141, \eta^2_p = .014$). The two personality meta-traits yielded a multivariate effect ($F_{2,602} = 3.29, p = .038, \eta^2_p = .011$), suggesting that EC men scored lower in emotional stability but not in plasticity. No multivariate effects were found for empathy ($F_{2,599} = 1.07, p = .344, \eta^2_p = .004$) or trust ($F_{3,518} = 0.64, p = .491, \eta^2_p = .004$). An effect of circumcision status was detected on sociosexuality ($F_{3,518} = 6.29, p < .0001, \eta^2_p = .035$), with EC men reporting higher levels of sociosexual desire, sociosexual behavior, and sociosexual attitude. A multivariate effect on sexual libido was found ($F_{2,519} = 5.82, p = .003, \eta^2_p = .022$), with EC men scoring higher in solitary and dyadic dimensions. Lastly, compared to NC, EC men reported
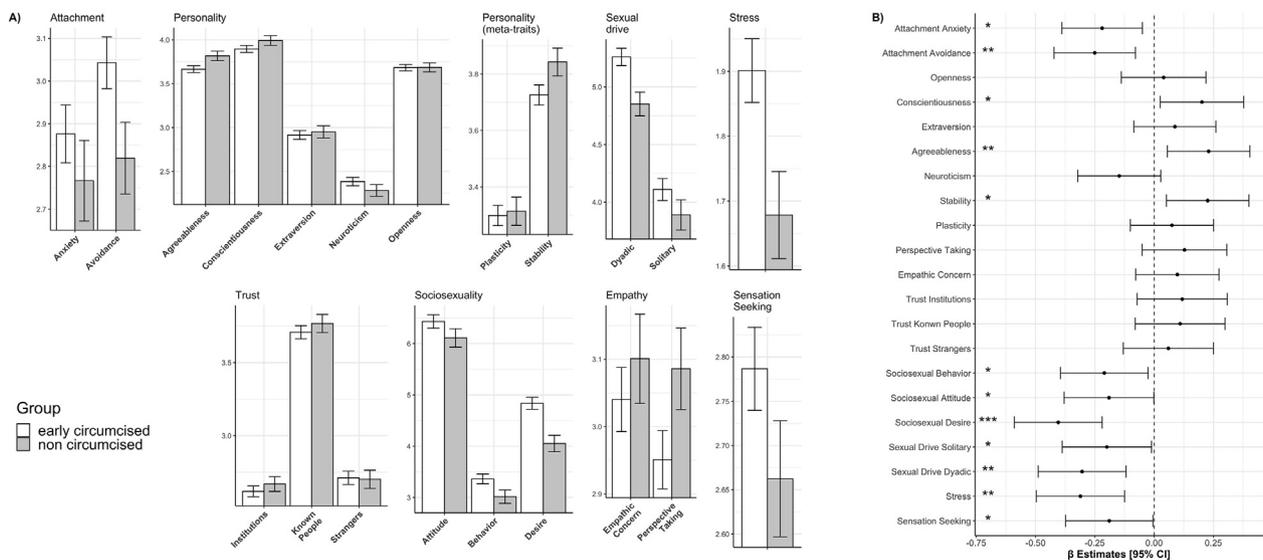

Figure 1. Left (A): raw group means (error bars: standard error of the mean) in psychological constructs for each group (early-circumcised and non-circumcised men). Right (B): estimated mean difference (standardized coefficients beta estimates, error bars: 95% CI) between group after correcting for age, ethnicity, and relationship status. Positive beta estimates indicate higher scores in the non-circumcised group; *p < .05; ** <.01; ***<.001.

higher levels of both stress ($F_{1,521} = 10.76$, $p = .001$, $\eta^2_p = .020$), and sensation seeking ($F_{1,550} = 4.08$, $p = .043$, $\eta^2_p = .007$). Univariate results are reported in Table 2 and displayed in Figure 1 before (left) and after (right) correcting for age, ethnicity, and relationship status. A correlation matrix for all the study's variables is presented in supplementary material SM3.

4. Discussion

The aim of this study was to investigate the possible long-term impact of neonatal circumcision on adult psychosocial outcomes. Unlike other studies that relied on mixed early- and late-circumcised men (Bollinger and Van Howe, 2011; Frisch and Simonsen, 2015a; Ullmann et al., 2017), here we specifically focused on the adult psychological profile of self-reported early-circumcised (within a month) men compared to non-circumcised. We hypothesized that early-circumcised men, compared to men who did not undergo neonatal circumcision, would display an alteration in socio-affective processing, characterized by higher attachment insecurity and emotional instability, lower empathy and trust, higher sexual libido and unrestricted sociosexuality (i.e., high number of sexual partners), and higher stress and risk-taking attitudes. Although all the associations that we found are in the direction of our hypothesis, contrary to our expectations, neither empathy nor trust were found to be affected by early circumcision. This being noted, our results are consistent with the view that neonatal circumcision has a long-term impact on adult behavior. Our findings are in line with research showing that neonatal circumcision affects parent-infant attachment. This is in accordance with life-history theory, which stipulates that early-life stress reduces reliance on one's social environment (e.g., opportunistic-exploitative interpersonal orientation), increasing stress, heightening sexuality, and increasing short-term mating and externalizing behaviors (Del Giudice, 2016; Del Giudice et al., 2005; Shakiba et al., 2020).

Although some studies have found that post-circumcision mother-infant bonding is disrupted, marked by altered breastfeeding and sleep patterns as well as higher infant irritability (Dixon et al., 1984; Marshall et al., 1980, 1982; Richards et al., 1976), other studies do not (Fergusson et al., 2007; Gattari et al., 2013; Mondzelewski et al., 2016). In this study, we found that EC men exhibited more anxious and avoidant attachment. For decades, investigators have advanced the view that the precursors of insecure attachment were lying in separation from, or inconsistent treatment by, primary caregivers in early life (Cassidy et al., 2013). Early attachment, crucial for the infant's neurobiological development (Schore, 2001), impacts both development and adult behavior (Bowlby, 1979). Longitudinal studies show that in six-month old infants, the quality of the mother-infant interaction predicted attachment security (Britton et al., 2006; measured with the Ainsworth et al. (1978) Strange Situation test). Also, early attachment security at 12 months has been found to predict the experience and expression of emotions at elementary school, at adolescence, and in the mid-twenties (Simpson et al., 2007). Moreover, early attachment security was found linked, 30 years later, to lower neuroticism and higher conscientiousness and agreeableness (Young et al., 2017), which, when aggregated, constitute the meta-trait stability (DeYoung et al., 2002). Consistent with longitudinal studies, we can preliminarily —but cautiously— link the adult attachment style of EC men with developmental factors, prompting more research to support this finding.

Our results showed that EC, compared to NC, men scored lower in emotional stability, a meta-trait of the Big Five composed of conscientiousness, agreeableness, and neuroticism (reversed). Low emotional stability has been linked to impaired functioning in emotional, motivational, and social domains (DeYoung et al., 2002, 2008). Several studies have linked insecure attachment and emotional instability to the rise of externalizing behaviors (e.g., aggression, hostility, impulsivity, antisocial behavior, hyperactivity, and drug abuse) and psychopathology (DeYoung et al., 2008; Green and Goldwyn, 2002; Paetzold et al., 2015).

Interestingly, preterm children who have spent early days in the neonatal intensive care unit (NICU) have persistently altered cortisol levels (Grunau et al., 2005, 2007) and altered breastfeeding patterns (Dodrill et al., 2008; Flacking et al., 2003; Maastrup et al., 2014) along with changed mother-infant interactions (Feldman, 2006), and are at higher risk of developing externalizing behaviors (Bhutta et al., 2002). This may be due in part to the invasive and painful, but life-saving, procedures performed in the NICU that affect structural brain development (Brummelte et al., 2012; Smyser et al., 2010), thereby having a long-term impact. These findings, together with our own results, suggest that neonatal circumcision may foster the development of attachment-related changes with implications for adult psychology or behavior.

We also found that early circumcision was associated with increased libido and sociosexual behavior. Studies on early stress show that precocious sexuality and unstable pair bonding are associated with insecure attachment (Belsky et al., 1991, 2012; Sung et al., 2016), and that individuals low in emotional stability are less likely to maintain stable relationships (Young et al., 2017), hence scoring high in sociosexuality. We found that the EC group also scored higher in sensation seeking. Sensation seeking is a potent predictor of a wide array of behaviors such as sexual risk-taking, reckless driving, smoking, alcohol use, and use of illicit drugs (Hoyle et al., 2002). The associations between sensation seeking, risk taking, and sociosexuality have been well established (Birnbaum, 2016; Penke and Asendorpf, 2008; Seal and Agostinelli, 1994; Simpson et al., 2004). Insecure individuals are more likely to have sex because of fear of abandonment and therefore to engage in sexual contact as an instrumental way of gaining reassurance (Birnbaum, 2016). Because risk taking often involves unprotected sex (Simpson et al., 2004), this suggests that unrestricted individuals who score high in sensation seeking might be at greater risk for contracting and spreading sexually transmitted diseases.

In our study, EC men reported higher levels of perceived stress compared to NC men. This is in contrast with one study that failed to reject the null hypothesis that circumcision alters neither psychological nor endocrine measures of stress (Ullmann et al., 2017). Yet, that study had insufficient statistical power (Boyle, 2017) to detect statistically significant differences between the groups (11 non-circumcised and 9 circumcised men, of whom 6 were circumcised with anesthesia and 3 were circumcised in infancy). Here, not only did we detect a statistically significant effect of perceived stress using a well-powered sample, but we have also provided theoretical reasons to link such stress in EC men to developmental factors. Because our EC sample was higher in attachment anxiety and emotional instability, this population may be less able to use secure-based strategies of social support-seeking that may lead them to use less effective means of social resources to cope with stress (Ein-Dor et al., 2018).

Although trust is a crucial part of a secure attachment (Joireman et al., 2002; Mikulincer, 1998; Rodriguez et al., 2015), contrary to our expectations, we did not find an effect of early circumcision on trust. While individuals with a secure attachment style tend to be confident, trust intimacy, and develop closeness, individuals with an insecure attachment style have difficulties in trusting and depending on others (avoidant style) or view others as undependable and untrustworthy (anxious style; Bogaert and Sadava, 2002). Our failure to detect an effect of circumcision on empathy should be noted. Exploratory work suggests a link between circumcision (192 neonatally circumcised and 44 later in life) and alexithymia (Bollinger and Van Howe, 2011) and between circumcision and a greater risk of developing ASD (Bauer and Kriebel, 2013; Frisch and Simonsen, 2015a), which, in turn, is associated with alexithymia (Berthoz and Hill, 2005; Frith, 2004; Hill et al., 2004). Studies on premature infants, who undergo invasive painful procedures in the NICU, have found that neonatal pain exposure was associated with reduced subcortical gray matter and reduced white matter in frontal and parietal regions (Brummelte et al., 2012; Smith et al., 2011), structures associated with empathic processing (Bernhardt and Singer, 2012; Decety and Jackson, 2004). Studies consistently show that alexithymia and

empathy scores correlate significantly (Banzhaf et al., 2018; Moriguchi et al., 2006), even when controlling for anxiety and depressive symptoms (Grynberg et al., 2010). We did however find that EC men scored lower than NC men in all measures of empathy and trust, despite the associated p value being greater than the pre-determined alpha level. We also report that these two constructs correlate negatively with both attachment avoidance and anxiety, replicating the findings of previous literature (Joireman et al., 2002; Rodriguez et al., 2015). Nevertheless, we report that the effect of circumcision on empathy and trust is negligible, at least in our sample.

4.1. Potential epidemiological implications

The psychological differences that we found between EC and NC men are not sufficiently severe in themselves to be suggestive of pathology. However, at the population level, where more than a half of US neonates undergo circumcision and 70–80% of US adult men have undergone early circumcision (AAP, 2012; Maeda et al., 2012; Morris et al., 2016), even small individual-level effects on psychosocial functioning may have meaningful cumulative implications. As discussed above, early-circumcision (similar to other neonatal surgical procedures, DeYoung et al., 2008; Green and Goldwyn, 2002; Paetzold et al., 2015) might be a concomitant factor for the emergence of such externalizing behaviors, especially in low socioeconomic contexts (Dodge et al., 1994). The present study did not explicitly examine externalizing behavior so we cannot test this hypothesis but recommend this analysis in future research, perhaps comparing EC boys/men with those born preterm who experienced early days in the NICU.

We found that EC, compared to NC, men reported higher sexual libido and sociosexual behavior. Assuming reasonably accurate self-reporting, EC men in our sample may therefore be more likely to engage in more sex with more partners than the NC men in our sample. Some surveys indicate that circumcised men are less likely to wear a

condom when engaging in heterosexual (but not homosexual, Mao et al., 2008) penetrative intercourse (Chikutsa and Maharaj, 2015; Crosby and Charnigo, 2013), that unrestricted individuals are more likely to engage in unprotected risky sexual intercourse (Seal and Agostinelli, 1994), and that individuals high in risk taking often engage in unprotected sex (Simpson et al., 2004). Overall, this might suggest an increased likelihood among EC men who score high in sociosexuality and risk-taking to spread sexually transmitted diseases; but more direct research on this question must be undertaken. We note that prior research suggesting a protective effect of circumcision on, e.g., transmission of the human immunodeficiency virus (HIV, female-to-male transmission only) concerned adult, voluntary circumcision later in life, not EC as explored in our study.

4.2. Limitations

Although our study provides potentially valuable information about the long-term psychological effects of neonatal circumcision, the results obtained should be tempered with an understanding of its limitations. Above all, we did not collect sociodemographic data such as religious affiliation and socioeconomic status that could have played a role in parent-infant relationships hence affecting attachment development. Our data is self-reported, and studies of this type are known to suffer from social desirability bias for sensitive topics, and low accuracy in self-assessment of circumcision status (at least in adolescents, Risser et al., 2004). Social desirability might have hindered participants from answering honestly on scales related to constructs known to be socially desirable (e.g., empathy, Watson and Morris, 1991). Although such a bias would be a systematic confound present in both EC and NC groups, we urge that future studies do not rely solely on self-reported questionnaires, or, at least, attempt to correct for social desirability bias.

MTurk populations, like ours, when compared to the US population as a whole, tend to be younger and more educated, but report lower
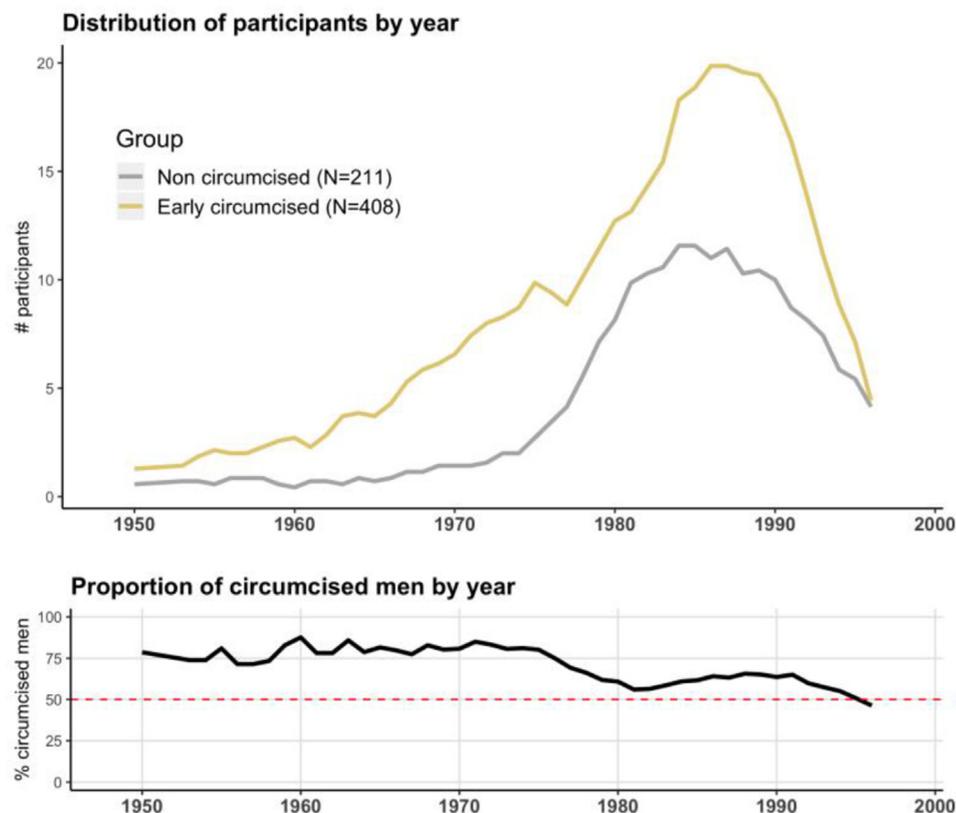

Figure 2. Distribution of year of birth (age) for early-circumcised and non-circumcised participants (above) and proportion of early-circumcised men (below).

incomes and higher unemployment (Stewart et al., 2017). Therefore, future studies need to be repeated with a sample of people that is more representative of the population and collect more sociodemographic variables to allow comparisons. To this end, we have provided a thorough description of our sample(s) in terms of demographic characteristics (see Table 1 and Figure 2) and provided complete statistics for our scales and results (SM2, SM3, and Table 2). It should be noted that our population was comparable to larger samples in terms of within-ethnicity proportion of circumcised men. Risser et al. (2004) investigated the circumcision status of 1508 adolescents (mean age in 2002 was 15 years) and reported that 58% of men within Black or African American, 22% men within Hispanic or Latino/a, and 82% men within White ethnic groups were circumcised. Similarly, we report that 61%, 27%, and 74% of men, within the same ethnic groups respectively, reported being early-circumcised. Moreover, our sample also shows a decreasing proportion of neonatal circumcision over the decades (see Figure 2), which has been shown in census data (Laumann et al., 1997; Wiswell et al., 1987, but see Morris et al., 2016). Another limitation is that our sample is composed of only US Americans. While this might pose a problem in terms of generalizability beyond this population, it is however a strength that, in the US, religion is less of a confounding factor with respect to circumcision, compared to samples drawn from European populations.

5. Conclusions

As a painful skin-breaking procedure, neonatal circumcision alters infant physiological and behavioral stress responses. Prolonged stress may have an effect on mother infant interactions and the development of an insecure attachment style. Here, we explored whether neonatal circumcision was connected with adult socio-affective processing associated with early stress. Our analysis shows differences between early-circumcised and non-circumcised men in psychological measures of socio-affectivity and provides initial support for the hypothesis that this alteration stems from the most crucial neurodevelopmentally plastic period of an individual's life. On a global scale, these small alterations might have meaningful social implications. Although we have used validated psychological instruments and provided a rich set of descriptive statistics that facilitate comparison to other studies, a replication of the current study with a larger sample size and better ability to control for socioeconomic variables is warranted. Longitudinal case-control studies from birth using the validated Ainsworth Strange Situation test to measure infant attachment would provide additional insights into how developmental history affects adult behaviors following neonatal circumcision.

Declarations

Author contribution statement

A. Miani: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

G. A. Di Bernardo: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

A. D. Højgaard, P. J. Zak, A. Landau: Analyzed and interpreted the data; Wrote the paper.

B. D. Earp: Wrote the paper.

J. Hoppe, M. Winterdahl: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

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