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RESEARCH REPORT

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The Effect of Baby Wearing on Atlatl Performance

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ABSTRACT
This analysis hypothesizes that baby wearing limits the performance capabilities of atlatl technology. If so, such hindrance would have disproportionately affected child caregivers who tend to be breastfeeding females and thus could have contributed to sexual division of subsistence labor among the many forager societies of the past that used baby-wearing and atlatl technologies. Contrary to expectation, experimental atlatl trials including a total of 208 casts fail to find any significant effect of baby wearing on atlatl accuracy or kinetic energy. The results suggest that the mechanical advantages of the atlatl system coupled with the conserved body motion entailed by the delivery mechanism make it possible to safely and effectively operate an atlatl with a baby in tow. Although this analysis does not preclude other limiting factors related to hunting with children, it nonetheless shows that atlatl technology could have been accessible to child caregivers.

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Hunter-gatherers; subsistence labor; gender; experimental archaeology; atlatl

1. Introduction

The atlatl is one of our species' most temporally and geographically pervasive hunting weapons (Bradley et al. 2010; Churchill 1993; Nuttall 1891; Toth and Schick 2007). Research suggests that atlatl technology may have made large-mammal hunting broadly accessible to female and male individuals of forager communities. An analysis of modern atlatl competition results shows that female and male atlatl performance is roughly equivalent, leading Whittaker and Kamp (2006, 219) to "[…] wonder if the atlatl […] serves as an equalizer, where body size and strength becomes less important for hunting success than in using a spear thrown by hand." A recent systematic comparison of experimental javelin and atlatl casts supports this hypothesis, showing a relationship between gender and javelin velocity but not between gender and atlatl dart velocity (Bebber et al. 2023). These studies thus indicate that atlatl technology equalizes projectile velocity, making projectile hunting relatively accessible to a broad spectrum of society.

Several scholars have furthermore observed that atlatl learning times are relatively rapid, which would have allowed females to approach peak proficiency before reaching reproductive age, thus reducing time conflicts and enhancing the accessibility of projectile technology (Grund 2017; Whittaker 2013), though current evidence remains statistically inconclusive (Breslawski et al. 2018). Moreover, in comparison to spears and javelins, the atlatl extends distances between predator and prey (Churchill 1993; Milks, Parker, and Pope 2019), which would have enhanced hunter safety – a particularly attractive feature to risk-averse child caregivers.

Archaeological evidence lends tentative empirical support for the hypothesis of female atlatl hunters. A systematic analysis of New World forager burials of the late Pleistocene and early Holocene – times when the atlatl would likely have been the major hunting technology – shows that females and males were equally likely, or nearly so, to have been interred with projectile technology (Doucette 2001; Haas et al. 2020; Smallwood, Haas, and Jennings 2023). Female burials with projectile weaponry, including actual atlatl parts, are furthermore observed among later assemblages (Guernsey and Kidder 1921; McGuire and Hildebrandt 1994; Snow 1946; Webb 1946). Given that sex, labor practice, and tools are widely associated with human burial practices (Binford 1971, 22), these observations suggest that the females buried with hunting tools were themselves hunters. Similarly, archaeological predictions deduced from models of Upper Paleolithic sexual division of labor have generally remained unmet (Lacy and Ocobock 2023).

Despite such theoretical and empirical observations, alternative models that envision more rigidly divided

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labor practice among forager societies of the past remain plausible. The empirical evidence for female hunting in the past is based on a limited sample and artifact associations that are the result of complex funerary practices and thus may not reflect female hunting per se (Kelly 2022, 49). Moreover, even if females and males share equal physical capacity for atlatl use (Bebber et al. 2023), childcare demands likely interfere with large-mammal hunting by females (Kelly 2013). There are several reasons why this might be so. Noisy and impatient children are likely to startle animals during search and pursuit. Slow-moving children impede travel to hunting grounds. Time allocation to childcare may limit hunting practice, reducing skill relative to male community members who do not face such tradeoffs to the same extent. Given that such dynamics would have disproportionately affected breastfeeding females (Lozoff and Brittenham 1979), their participation in large-mammal hunting would have been curtailed (Kelly 2022, 48–49).

Previous scholars have found empirical support for this hypothesis, observing pronounced sexual division of subsistence labor among ethnographic forager societies with males as hunters and females as gatherers and processors (Grund 2017; Kelly 2013; Kuhn and Stiner 2006; Waguespack 2005). Although recent studies suggest that such division may be less pronounced than previously thought (Anderson et al. 2023; Ocobock and Lacy 2023), there does appear to be a strong degree of sexual division of subsistence labor in ethnographic subsistence practices, indicating that some factor other than physical capacity – perhaps childcare or cultural restrictions – favors male participation in large-mammal hunting (Hoffman, Farquharson, and Venkataraman 2021; Venkataraman et al. 2024).

While childcare seems likely to contribute to sex-based differences in atlatl hunting, the extent to which this is so has not been systematically examined. We could suppose that childcare makes atlatl hunting impossible or at least economically unprofitable for the reasons outlined above. Yet, it is also possible that childcare effects do not obviate female hunting and could even be inconsequential under certain ecological, technological, and social conditions (Bird 1999). First, females are not always with children, which ought to foster a degree of variability in subsistence pursuits throughout a female's lifetime (Doucette 2001). An ethnographic review of forager childcare practices suggests that children spend 50% of their time away from mothers, and that fathers frequently contribute to childcare at equal or greater rates than those observed in non-forager societies (Lozoff and Brittenham 1979). Second, when large mammals are abundant or naïve to human predation, such as during peopling events (Berger, Swenson, and Persson 2001), or when large-mammal hunting takes the form of cooperative drives (Noss and Hewlett 2001), startling animals is irrelevant and can even be desired in the case of animal drives, thus incentivizing female hunting even with children in tow. Third, when residential mobility is high and brings forager camps into close proximity with prey (Goodman et al. 1985), the challenges of child transport are reduced (Surovell 2000) and can be more easily mitigated via shared care, or alloparenting (Elston, Zeanah, and Codding 2014; see also Hrdy 2009). Fourth, in temperate climates where relatively little labor is required for the production of thermoregulatory technologies, female labor may be profitably allocated to hunting (Kelly 2022, 49). Finally, baby-carrying technologies can affect the accessibility of subsistence pursuits. For example, a cross-cultural ethnographic survey shows that the presence of baby-carrying technology correlates with female participation in subsistence labor (Kushnick 2021), and scholars have posited that such technologies could have played a prominent role in our species' behavioral evolution (Tanner and Zihlman 1976; Taylor 2010).

At a theoretical level, the extent to which ecological, technological, and social conditions ought to shape variation in large-mammal hunter demographics remains unclear. To advance our understanding of the influence of childcare on subsistence labor, this analysis examines one of the potentially important dynamics affecting sexual division of hunting labor in atlatl-using forager societies – the extent to which baby wearing affects atlatl performance. Baby wearing is the act of transporting a child on one's body with a carrying device and is a widespread practice across human societies including foraging societies, past and present (Bordreau 1974; Camp 2017; Kluckhohn, Hill, and Kluckhohn 1971; Kushnick 2021; Lee 1979; Lozoff and Brittenham 1979; van Hout 2011; Wall-Scheffler, Geiger, and Steudel-Numbers 2007). Given the expansive geographic and temporal distribution of atlatl and baby-wearing technologies, the dynamics examined here are likely to transcend ecological context. At face value, baby wearing would seem to introduce performance constraints that would have made atlatl hunting unproductive or even impossible for child caregivers. Baby wearing limits body motion, thus potentially limiting the ability to engage the dart-firing mechanism. Carried babies are likely to distract hunters and may even mechanically interfere with weapon delivery, reducing hunting success rates. Moreover, it seems possible that baby wearing could pose a threat to the child whether from the jolt in throwing action or blunt force trauma induced by the atlatl or dart, any combination of which could conceivably induce harmful or lethal shock to a child. Such dynamics would have ostensibly disadvantaged females in hunting pursuits and thus could have discouraged female participation in large-mammal hunting, favoring male use of projectile weaponry and, consequently, sexual division of subsistence labor. However, the extent to which such dynamics are a concern is unknown.

This analysis is concerned not only with whether baby wearing precludes atlatl use but also whether or not losses in accuracy or power are of sufficient magnitude to economically discourage baby-wearing parents – typically females due to the biological constraint of breastfeeding – from engaging in large-mammal hunting.

2. Model and expectations

A simple economic model is developed to formalize this intuition and generate more precise predictions for the circumstances under which we should expect a child caregiver to include or exclude atlatl hunting in their subsistence repertoire. With firearms or archery technology, large-mammal hunting can generate post-encounter return rates on the order of 20 kcal/h, ranging between 30 and 15 kcal/h depending on taxon (Joyce, Louderback, and Robinson 2021). Accounting for the fact that expert atlatlists can hit a typical kill zone of 24 cm in diameter with a 40% success rate (Whittaker 2013), adjusted post-encounter return rates using an atlatl could be expected to be on the order of 8 kcal/h for typical large mammals. Such post-encounter return rates are 60% greater than typical returns for the most productive plant-foraging endeavor – tuber foraging, which tends to generate post-encounter return rates on the order of 5 kcal/h (Joyce, Louderback, and Robinson 2021). Baby wearing would have to further reduce atlatl accuracy by at least 38% to reduce hunting return rates below that of tuber foraging and thus justify a shift in economic prioritization from atlatl hunting to plant foraging (Figure 1). Notably, this is a conservative estimate, which assumes childcare does not affect return rates for tuber foraging. Yet, as any parent knows, few tasks go unimpeded by children, and this certainly would have included foraging. For the sake of this analysis, we cautiously make the assumption of unhindered plant-foraging rates while remaining alert to this potential analytical confound.

Not only is baby wearing expected to reduce atlatl accuracy, it is also expected to reduce the kinetic energy of a cast atlatl dart, which could reduce return rates to the point that plant foraging would be more profitable than large-mammal hunting. A previous study suggests

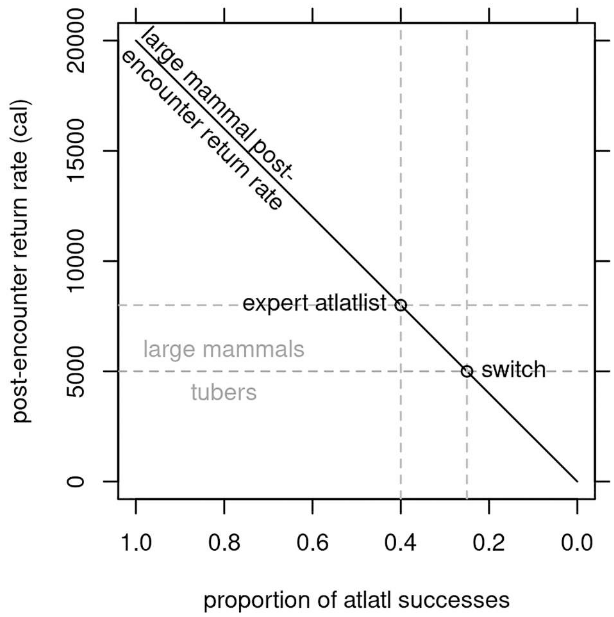

Figure 1 Baby wearing would have to reduce atlatl accuracy by 38% to justify a switch to tuber foraging. Unhindered atlatl experts hit a typical large-mammal kill zone of 24 cm in diameter just 40% of the time (Whittaker 2013), which reduces large-mammal post-encounter return rates from 20 to 8 kcal/h. An additional 38% loss in accuracy, from 40% to 25%, would reduce hunting returns to the level of tuber foraging – the most calorically productive form of plant foraging (Joyce, Louderback, and Robinson 2021).

that projectile systems must generate at least 34 J to reliably hunt mammals weighing more than 33 kg, which includes commonly hunted large-mammal species in the Americas such as deer, guanaco, pronghorn, and vicuña (Tomka 2013). If baby wearing reduces average kinetic energy values below 34 J, then we would conclude that baby wearing can contribute to sexual division of subsistence labor.

Collectively, if evidence reveals that baby wearing either impedes atlatl accuracy or kinetic energy to the point that foraging is more profitable than hunting, then we would find support for the hypothesis that the intersection of atlatl and baby-wearing technologies catalyzed gendered division of subsistence labor in forager societies of the past. Otherwise, we conclude that atlatl technology was accessible to child caregivers and that baby wearing cannot account for sexual division of subsistence labor among atlatl-using forager societies of the past.

3. Materials and methods

Today, few if any human societies routinely engage in large-mammal hunting with atlatl technology, making it impossible to ethnographically evaluate atlatl proficiency in the hands of professional atlatl hunters

(Whittaker and Kamp 2006). This study, therefore, takes an experimental approach to evaluating the effects of baby wearing on atlatl accuracy and kinetic energy. The experiment leverages a convenient opportunity for an experienced atlatlist – the author – to perform atlatl trials with and without their one-year-old in a baby-wearing device (Figure 2). Steps are first taken to evaluate and ensure the safety of the task. Then, repeated casts with and without baby wearing are performed to assess effects on atlatl performance. Randomization procedures and mixed-effects modeling are used to control for random effects. Here, we detail the materials and methods used to assess the hypothesized relationship.

3.1. Materials

The materials of this analysis included an adult atlatlist, baby, baby-wearing device, atlatl, atlatl target, and measuring tape. The atlatlist was the author – an average-sized U.S. adult male, 1.75 m tall, weighing 75 kg. He has been avocationally making and using atlatls for over 20 years. The baby is the author's one-year-old son, who weighed approximately 11.5 kg. The baby was fastened to the author's back using a simple stitched-cloth baby carrier manufactured by BabyHawk (Figure 2(a); Figure S1). This carrier was used because of its simplicity, its functional similarity to common ethnographic forms, and because it is the carrier the author routinely uses for baby transport in other contexts.

The experimental atlatl is loosely modeled after Basketmaker II atlatl systems from the US Southwest. This model was chosen in part because it is among the best documented archaeological atlatl systems in the world with multiple complete or near-complete examples published (Guernsey and Kidder 1921; Kidder and Guernsey 1919; Lindsay 1968; Nusbaum, Kidder, and Guernsey 1922). Moreover, such forms are relatively common in the archaeological record of the Americas with comparable artifacts observed in Late Holocene contexts of the Andes (Distel and Alicia 1986), Florida (Gilliland 1975), Great Basin (Tuohy 1982), Ozarks (Pettigrew 2017), and Rocky Mountains (Frison 1965). The experimental atlatl used here was made from osage orange (*Maclura pomifera*) heartwood and measured 58.8 cm in length, 2.3 cm in maximum width, and 0.8 cm in maximum thickness (Figure 2; Figure S2). Finger loops were made from whitetail deer (*Odocoileus virginianus*) leather attached with deer sinew coated with deer-hide glue. An atlatl weight made from a sandstone river cobble was attached to the approximate center of the atlatl board using deer sinew coated with deer-hide glue. The finished product weighed 129 g.

The mainshaft of the atlatl dart was made from a willow (*Salix exigua*) shoot measuring 134.5 cm with a maximum diameter of 10.2 mm at the distal end and a minimum diameter of 5.8 mm at the proximal end. The willow shoot was harvested in the summer, peeled green, allowed to dry for several weeks, and sanded with 60 grit sandpaper. The mainshaft socket was

Figure 2 Experimental design: (a) time series showing a single dart cast (atlatl and dart, baby in baby-wearing device, and target are visible; laptop for sound recording is out of the scene on the trailer to the left); (b) atlatl and dart (additional details in Figure S2).

reamed with a power drill, and the hook socket was manually reamed with a knife. Both ends of the main-shaft were reinforced with deer-sinew wraps coated in hide glue. The fletching consisted of three whole (i.e., unsplit) wild turkey (*Meleagris gallopavo*) feathers lashed with deer sinew and hide glue.

The dart foreshaft was made from red osier dogwood (*Cornus sericea*) and tipped with a steel field point measuring 9.5 mm in diameter and weighing 12.4 g. The tip was secured with JB Weld™ cold weld two-part epoxy. The foreshaft was socketed and secured to the mainshaft with deer-hide glue. The completed atlatl dart measured 148.3 cm in length and weighed 77.2 g.

Effort was made to use a single dart throughout the experiment to control for variation in dart characteristics. However, a second dart was made and used after the first dart broke during trial 7. Effort was made to keep all design steps constant, recycling the same feathers and sinews. The mainshaft socket was manually reamed with a flaked stone drill. This manufacturing deviation from the previous dart was taken because power-drill reaming of the first shaft created a weak spot in the mainshaft that contributed to its failure. The completed replacement dart measured 147.2 cm in length and weighed 75.1 g.

3.2. Safety and efficacy assessment

Prior to data collection, and in coordination with the baby's mother, the author slowly worked up to using the atlatl with the baby on his back to ensure that it could be accomplished safely. All experiments were done with the consent of the baby's father (the author) and mother and with the baby's assent.

3.3. Performance assessment

For systematic data collection, a 30″ × 30″ crossbow target manufactured by BIGshot was faced with a custom-made target poster for recording inaccuracy. The target displayed a polar coordinate grid system with distance circles radiating every cm to 38 cm from the target center and radial lines at 5-degree intervals labeled clockwise with 0 degrees oriented up (Code S1). This target system allowed for accuracy documentation and reliable digital plotting of spatial distributions of target hits.

Estimates of kinetic energy were calculated from dart-mass and dart-velocity measurements such that kinetic energy equals mass/2*velocity^2. Dart velocity was measured using an acoustic method, which produces inaccuracies on the order of 1% (Courtney 2008). Although previous atlatl ballistics studies have deployed radar guns (Whittaker, Pettigrew, and Grohsmeyer 2017), a systematic investigation shows that they systematically underestimate velocities by 3.4–14.3% due to limitations of Doppler measuring mechanism (Robinson and Robinson 2016). The laptop computer used in this experiment was a Dell Latitude 7420 with eight 2.80 GHz 11th Gen Intel® Core™ i7-1165G7 processors, 16GB RAM, and a Mesa Intel® Xe Graphics (TGL GT2) card. Audacity® software (Audacity Team 2021) was used for recording the experimental atlatl acoustics, visualizing the acoustic profiles, and measuring the times-of-flight. Acoustic profiles were visualized as waveform spectrograms to identify the dart release and target impact moments (Figure 3).

Target distance was held constant at 6.00 m with the launch line demarcating the boundary of leading foot of the atlatlist. This distance was qualitatively chosen to simultaneously minimize target misses while maximizing spatial variation in hits. The computer was placed on a low table next to the atlatlist for sound recording. Ten randomly ordered trials, including five control trials (without baby) and five treatment trials (with baby), were spaced out over several months. Each trial attempted to achieve 30 consecutive casts. A fresh target cover was used for each trial. Shot location was recorded using the target's polar coordinate grid. Inaccuracy was measured to the nearest centimeter as distance from the center of the target. Radial position was documented to the nearest five degrees. Time-of-flight for each shot was derived from sound files immediately after each trial.

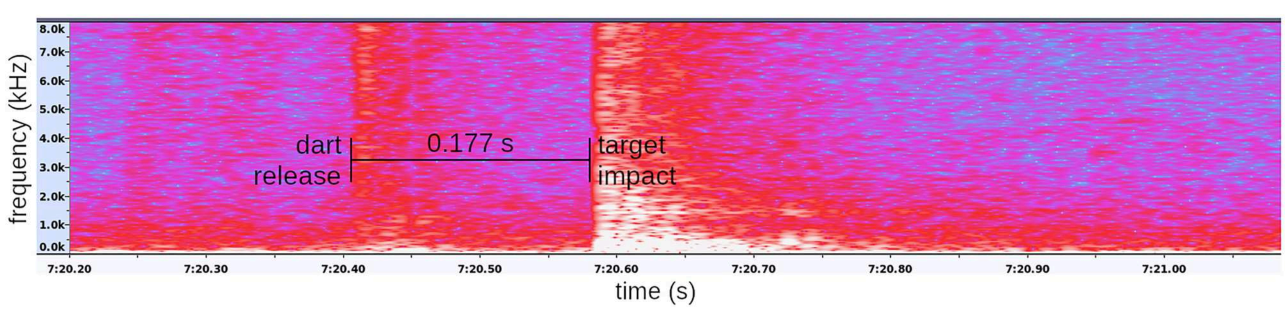

Figure 3 Example of an acoustic spectrogram in waveform for one atlatl cast created using Audacity audio editing and recording software (Audacity Team 2021). The spectrogram shows the moments of dart release and target impact. The time-of-flight time is measured from the spectrogram and used in the derivation of dart velocity and kinetic energy.

3.4. Data analysis

All data measurements were entered into a spreadsheet, which was imported into R statistical computing environment (R Core Team 2023) for analysis. Data were visually inspected using radial plots (Lemon 2006) and histograms. Accuracy and kinetic energy results for the control and treatment data were compared using box-and-whiskers plots and KS tests. Hit:miss data were also used to assess accuracy with control and treatment compared using a Chi-square test. A linear mixed-effects model (Bates et al. 2015; Kuznetsova, Brockhoff, and Christensen 2017) was used to determine the effect of baby wearing on dart performance given potential confounding effects associated with the specific trial conditions, shot order, and dart. All code is reported in Supplementary Online Materials (Code S2).

4. Results

Preliminary unstructured tests revealed that the atlatl can be used safely with the baby in the baby carrier (Video S1). We furthermore observed that the baby was quite engaged and happy to participate, silently focusing on the target prior to each cast and often giggling after. These basic qualitative observations show that baby wearing does not categorically preclude atlatl use and that more systematic analysis can be safely conducted to determine effect size.

The systematic portion of the experiment resulted in 208 casts distributed across 10 separate trials (Tables S1 and S2). Five of the trials were control trials conducted without the baby, which produced 136 casts. The other five trials were treatment trials, conducted with the baby, and produced 72 casts. The baby's patience for repeated casts was limited, resulting in roughly half the number of casts for the treatment relative to the control. At first blush, this dynamic might suggest a constraining factor on atlatl use. However, given that hunting events rarely require many repeated casts from a single location, it is unlikely that this particular dynamic pertains to real-world hunting situations. That the baby was agreeable to participation in every trial, with each trial yielding 7–20 casts (see Table S1), is the salient observation and shows that baby wearing is not categorically antithetical to atlatl hunting.

4.1. Inaccuracy results

Inaccuracy, expressed as distance from center of target, was recorded for 177 casts – 116 without and 61 with the baby. In addition, 31 missed shots were recorded. Inaccuracy readings average 18.7 cm (5.0–41.6 cm 95% range) for all shots, 18.2 cm (3.9–41.1 cm 95% range) without the baby, and 19.7 cm (6.0–41.0 cm 95% range) with the baby (Figure 4(a)). No statistically significant difference is observed between the control and treatment outcomes (KS test $D = 0.10$, $p = 0.68$). Moreover, hit:miss frequencies of 116:20 for the control and 61:11 for the treatment are statistically indistinguishable ($\chi^2 = 0.00$, $p = 1.00$).

Inspection of the accuracy measurements shows the data to be relatively modal in aggregate and across trials suggesting that the results are relatively immune to random effects associated with the research design (Figure 5). The mixed-effects model, which assesses random effects related to individual trial conditions, shot order, and dart (two different darts of near-equal form were used due to breakage of the first dart), indicates that baby wearing induces a statistically insignificant ($p = 0.71$) decrease in accuracy of just 0.7 ± 1.9 cm.

The mixed-effects model estimates median inaccuracy without a child to be 21.5 cm (0.3—42.5 cm 95% range) and with a child to be 21.8 cm (0.7–42.5 cm 95% range). These results translate to a mere,

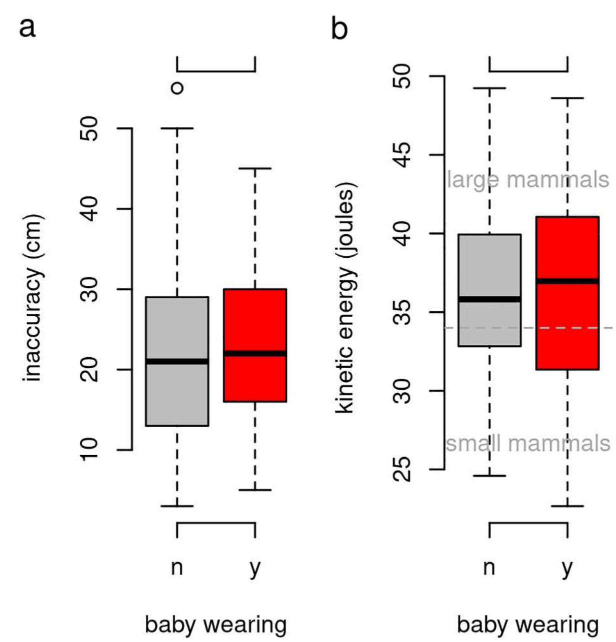

Figure 4 Experimental results for accuracy and kinetic energy tests with and without baby wearing showing no clear difference between the controls and treatments: (a) aggregate inaccuracy measurements with and without baby wearing reveals little effect of no significant difference (KS test $D = 0.10$, $p = 0.68$); (b) aggregate kinetic energy measurements similarly showing little effect of no significant difference (KS test $D = 0.10$, $p = 0.80$) with values consistently above 34 J (dashed gray line) and thus sufficient for large-mammal hunting (Tomka 2013) (thick horizontal lines = median, box-and-whiskers reflect quartile ranges).

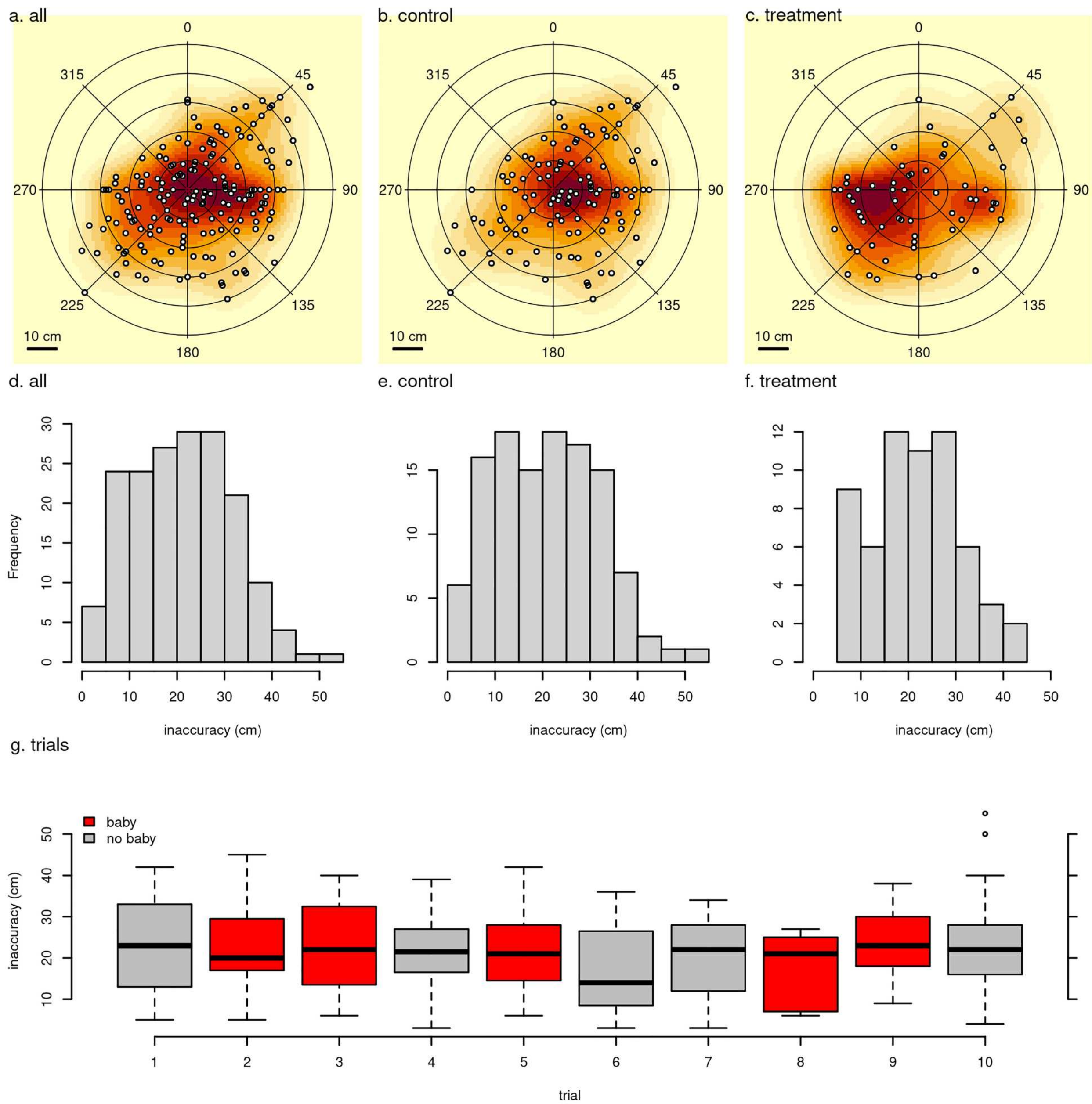

Figure 5 Accuracy measurement data showing no apparent difference between the control and treatment shots: shot placement for (a) all shots, (b) control shots without baby, and (c) treatment shots with baby; kernal density plots (Venables and Ripley 2002) shown in backgrounds at 1 cm resolution; inaccuracy measurements for (d) all shots, (e) control shots without baby, and (f) treatment shots with baby; (g) inaccuracy measurements by trial for control and treatment shots.

statistically insignificant loss of 1.6% in median accuracy. We therefore fail to find support for the expectation of a 38% accuracy loss that would economically compel an individual to favor plant foraging over atlatl hunting.

4.2. Kinetic energy results

Kinetic energy is observed for 161 casts, 105 without baby and 56 with baby. Kinetic-energy estimates are not possible for 47 shots due to target misses or poor sound readings. Average kinetic energy is 35.8 J (24.6–46.2 J 95% range) for all casts, 35.9 J (28.1–46.2 J 95% range) for control shots without the baby, and 35.5 J (23.4–44.8 J 95% range) for treatment shots with the baby (Figure 4(b)). These control and treatment values are not statistically different (KS test $D = 0.10$, $p = 0.80$). Inspection of the kinetic-energy measurements shows the data to be relatively modal in aggregate with some systematic variation across trials (Figure 6), suggesting that the conditions of specific trials could have confounded the results. However, a linear mixed-effects model evaluating

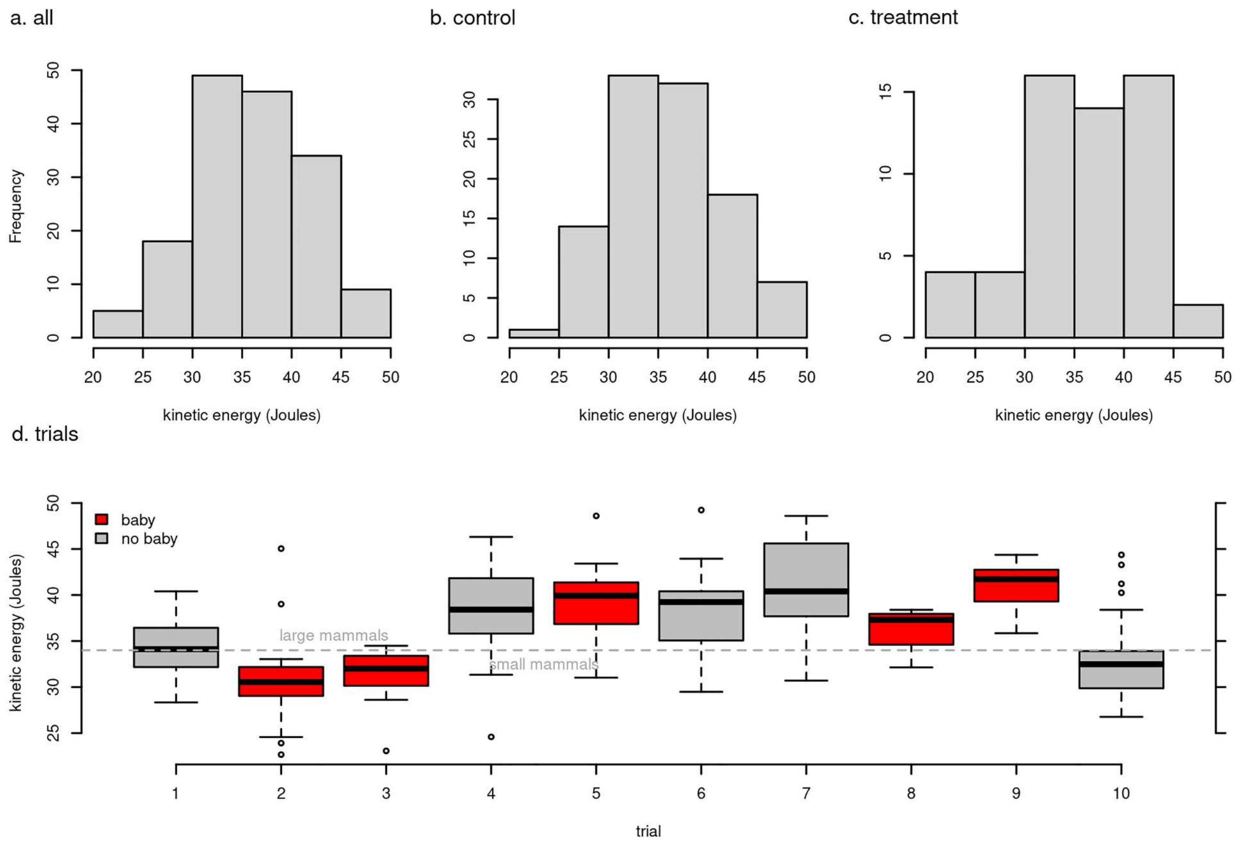

Figure 6 Kinetic energy data showing no apparent difference between the control and treatment shots: kinetic energy measurements for (a) all shots, (b) control shots without baby, and (c) treatment shots with baby; (d) kinetic energy measurements by trial for control and treatment shots.

kinetic energy as a function of baby wearing with trial number, shot order, and dart as random effects reveals a statistically insignificant ($p = 0.74$) loss in kinetic energy of just 0.9 ± 2.5 J with baby wearing.

The estimated kinetic-energy medians derived from the linear mixed-effects model for the first shot after 10 trials without a child is 37.0 J (28.8–45.7 J 95% range) and with a child is 36.1 J (27.4–45.0 J 95% range). All average-value estimates exceed the minimum kinetic energy threshold of 34 J for large-mammal hunting. We, therefore, fail to find support for the expectation of a kinetic energy drop below the large-mammal hunting threshold, which would compel a child caregiver to favor tuber foraging over atlatl hunting. Moreover, we fail to detect any loss in kinetic energy due to baby wearing.

5. Summary and discussion

This analysis began by considering the effects of childcare on large-mammal hunting. It was hypothesized that some aspect of childcare is likely to impede large-mammal hunting and thus encourage sexual division of subsistence labor. Toward understanding this dynamic, the analysis examined the intersection of two of the most pervasive technologies in forager societies – the atlatl and baby carrier. Specifically, the analysis examined the extent to which baby wearing affects atlatl performance and whether the effects are sufficient to incentivize a child-caregiver – most often female due to the biological constraint of breastfeeding – to lay down their atlatl in favor of plant foraging. We reasoned that baby wearing would have to reduce atlatl accuracy by at least 38% or kinetic energy below 34 J to economically justify a shift from atlatl hunting to foraging. Not only did the experimental trials reported here find that baby wearing does not reduce performance to those levels, the experiment further failed to observe any statistically significant relationship between baby wearing and atlatl performance. The finding suggests that baby wearing would have been insufficient to discourage atlatl hunting among child caregivers. To the contrary, in this regard, atlatl technology would have been accessible to a broad spectrum of society that included child caregivers.

This finding runs counter to the working hypothesis, which anticipated some detectable effect on atlatl performance. Why this expectation was unmet became qualitatively apparent during initial testing. The mechanics of atlatl use entail relatively conserved body mechanics that are unimpeded by the baby or wearing device and are in no way detrimental to the baby. Indeed, the baby seemed engaged in the activity and frequently expressed joy (laughter) after dart casts. Quantitative data extended the qualitative observation by showing no statistically significant loss in dart accuracy or momentum. Clearly atlatl mechanics not only enhance projectile performance, they also enhance capacity for baby wearing through the conserved body motion entailed by the mechanics of projectile delivery.

This finding aligns with two previous studies, which observe that female and male atlatlists perform similarly (Bebber et al. 2023; Whittaker and Kamp 2006). Moreover, atlatl technology would have been attractive to risk-averse caregivers because atlatls would have been safer to use than predecessor technologies, spears and javelins. Whereas such technologies require close engagement with large animals, the atlatl can be fired effectively at distances of 30 m (Churchill 1993; Milks, Parker, and Pope 2019), reducing the risk of prey-induced injury to the hunter or child. I further suspect that the operation of the spear or javelin would have required greater body motion and jolt, which would potentially injure a baby in tow. Assuming these dynamics to be true, then spears and javelins would have discouraged female use of those weapons, thus widening the gap in sexual division of labor under that technological milieu, in which case the atlatl would have increased equity in access to hunting technology (Bebber et al. 2023).

Although this analysis supports the conclusion that baby wearing did not affect atlatl accessibility, several potential analytical confounds must be recognized. First, although this experiment benefits from multiple trials and hundreds of dart casts that control for statistical uncertainty and variability in participants, equipment, and conditions, the conclusion is based on an experiment performed by a single individual from a different socioeconomic background than the one under consideration. Unfortunately, we will likely never have the opportunity to assess these dynamics among actual atlatl hunters (Whittaker and Kamp 2006), and we are resigned to experimental approaches and ethnographic approximations. A major challenge facing experimental approaches is in mustering multiple individuals – particularly baby participants and competent atlatlists – to reproduce the experiment. The current experiment is opportunistic, leveraging the intersection of author's experience with atlatl technology and his current parental situation. Ultimately, additional experiments by other investigators would be valuable for further evaluation of the findings reported here. This analytical approach will necessarily be a distributed effort among many experimenters and babies over many years as opportunity allows.

Another experimental approach that could be used to address sample-size limitations might entail experimental atlatl use with and without a weighted pack. Such an approach would not only increase the number of atlatl participants, it would also allow for participant-blind testing to reduce potential implicit bias effects. Despite such experimental advantages, a weighted-sack approach is limited insofar as it would not permit assessment of the effects of baby behavior and it would be fundamentally unable to increase the sample of baby participants. In other words, such an approach would be incapable of addressing the extent to which baby behavior affects atlatl performance. Thus, such an experiment with its advantages and limitations would be complimentary to the current study and would be a valuable contribution.

Another useful approach to circumvent novice effects associated with experimental approaches might entail the use of ethnographic analogs where professionals deploy similar technologies under similar economic circumstances. One such analog involves contemporary Quechua and Aymara herders of the Andes Mountains who use stone slings in daily herding practice. Sling mechanics are similar to atlatl mechanics. Andean slings, locally known as *hondas,* consist of two cords attached to a woven pouch designed to loosely hold a small rock, which is cast using circular throwing motion and release of one cord (Figure 7). Typically, *hondas* are made from woven camelid or sheep fiber. Andean herders use these devices to launch stones into brush in advance of straying herd animals including alpacas, llamas, sheep, and other livestock to startle and redirect them. *Hondas* are also sometimes deployed as weapons during inter-personal conflicts (Vega and Craig 2009). Both *hondas* and atlatls are two-part projectile technologies used for large-mammal pursuits and inter-personal conflict. Thus the mechanics and contexts of atlatl and *honda* use are similar, and cautious comparisons can be instructive.

Given the similarities in mechanics and contexts of use, we might expect the demands of childcare to similarly impinge upon *honda* use in ways that make females less effective herders, which would in turn make them less likely than males to participate in herding and sling use. However, contrary to this intuition, a study of 142 Andean sling users observed that 69 were female and 73 were male – a ratio that is in statistical parity ($\chi^2 = 0.11$, $p = 0.73$), suggesting that females and males are just as likely to use slings (Vega and Craig 2009). Furthermore, "Virtually all of the individuals in the

Figure 7 Quechua woman using a stone sling. Quechua females and males use stone slings for herding large mammals – llamas, alpaca, sheep, goats, cattle, and donkeys. Females and males also use them in conspecific conflict. The dynamics and context of sling use are similar to atlatl hunting of naïve prey, cooperative hunting, and inter-personal conflict, suggesting that atlatl use could have been similarly non-gendered.

[…] study reported that women more commonly use slings today" (Vega and Craig 2009, 1268).

Although Brown Vega and Craig's analysis did not report baby wearing, Luz Fiorela Incacoña Vilca – an Aymara herder and colleague from Comunidad Totorani, Puno, Peru – informs me that baby-carrying women routinely use *hondas* when herding albeit at some loss in performance. The sum of quantitative and qualitative observations thus indicates that child-care challenges are insufficient to warrant sex-biased sling use or sexual division of labor among Andean herders. The observations of non-gendered use of Andean slings – and possibly even female-gendered use of those tools – indirectly support the hypothesis that females are not systematically excluded from the use of atlatl technology. Additional ethnographic evaluation of these dynamics would be valuable.

A second potential analytical confound is the gender of the experimenter. Given that this analysis is largely about female atlatl use, it might seem preferable that a female atlatlist perform the experiment. This consideration follows from the assumption that human body dimorphism might somehow interact with baby wearing and atlatl performance. I suspect that such effects are trivial, particularly given that recent research shows no relationship between gender and atlatl performance (Bebber et al. 2023). Moreover, baby wearing by male adults certainly occurred to some extent (Gettler 2010). Nonetheless, other scholars may have reason to suspect that the interactive effects of gender and baby wearing are pertinent, in which case systematic assessment would be valuable. Such analysis awaits the timely co-occurrence of an interested female atlatlist with a child.

A final variable – though not necessarily confounding – worth further examination is baby-wearing strategies. Baby-wearing practices are diverse, involving different kinds of devices and positioning of adult and

Figure 8 Observation of an individual – Todd Surovell – successfully operating an atlatl with baby in a dorsally positioned carrier.

child bodies (Bordreau 1974; Camp 2017; Kluckhohn, Hill, and Kluckhohn 1971; Kushnick 2021; Lee 1979; Lozoff and Brittenham 1979; van Hout 2011; Wall-Scheffler, Geiger, and Steudel-Numbers 2007; Wu, Huang, and Wang 2016). Efforts to assess the effects of baby-carrier variability on atlatl performance would be valuable for generating a more complete picture of the effects of baby wearing on atlatl use. As an anecdotal observation, I have observed my colleague, Todd Surovell, successfully use an atlatl with his infant in a front-carrying device (Figure 8; Video S2). Similarly, evaluation of alternative atlatl forms, particularly large forms such as those from Australia (Gould 1970), would be worthwhile.

6. Conclusion

While recognizing the need for additional investigation, the results of this analysis reveal that atlatl technology likely made engagement with large mammals accessible to child caregivers who are most often females due to the biological constraint of breastfeeding. In our effort to understand the ways that childcare may have affected division of labor in forager societies, we discovered – counter to guiding intuitions – that baby wearing does not affect atlatl use. This conclusion does not mean that other aspects of childcare would not have limited hunting opportunities. Of particular note, the potential of children to startle game would seem to be a strong deterrent in large-mammal hunting, at least in solo or small-group hunting events. But again, under certain ecological conditions such as when prey are naïve (Berger, Swenson, and Persson 2001), communally hunted (Noss and Hewlett 2001), or proximate to camp (Goodman et al. 1985), such limitations may be relaxed to the point that they do not deter female hunting. We could further suppose that pregnancy could diminish atlatl performance, but the extent to which this is so remains unknown.

The current analysis, which fails to find an effect of baby wearing on atlatl performance, demonstrates that one of humanity's most pervasive hunting technologies was unlikely to have induced sexual division of labor among early forager societies. Archaeological evidence, which reveals multiple instances of females interred with projectile weaponry, and occasionally atlatl parts, would seem to indicate that females indeed leveraged the economic potential of atlatl technology to hunt large mammals. If such archaeological associations have led us astray and past females were not atlatl hunters, then some other dimension of childcare, sex or gender difference, or power relations structured sexual division of labor in the past. Additional research on the effects of child behavior on hunting returns are sorely needed. For now, the prudent explanation for the archaeological patterns would seem to be that sexual division of subsistence labor was greatly attenuated among past foragers who may have wielded atlatls while baby wearing.

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